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Esthetically, a stream can be affected by the dark color of the water coming from a log pond or wet deck. Floating bark from a log raft or a log pond is also aesthetically displeasing. The most significant problem associated with log rafting is the loss of bark which commonly occurs when the logs are dumped into the water.

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EFFECTS OF LOG HANDLING AND STORAGE ON WATER QUALITY

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environment Research Laboratory - Cincinnati (IERL-CI) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report reviews the biological and chemical effects of three types of log storage on water quality. This study was a part of the general EPA research program to determine the effects of all industrial and agriculture activities on water quality and was undertaken because there was little information available on the effects of logging.

The report also identifies the problems associated with log storage and provides facts upon which to base regulations controlling log storage to minimize environmental impact. The report can be used by state and federal regulatory agencies and will also be of interest to industries involved in log storage and handling. For further information please contact the Food and Wood Products Branch of the Industrial Environmental Research Laboratory, Cincinnati.

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Director
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ABSTRACT

The biological and chemical effects of three types of log storage on water quality were investigated. Three flow-through log ponds, two wet deck operations, and five log rafting areas were studied. Both biological and chemical aspects of stream quality can be adversely affected by flow-through log ponds and runoff from wet decks. Severity of degradation varies widely with each situation. Runoff from wet decks had pollution characteristics equal to or greater than that of the waters from the flow-through log ponds studied.

Esthetically, a stream can be affected by the dark color of the water coming from a log pond or wet deck. Floating bark from a log raft or a log pond is also aesthetically displeasing. The most significant problem associated with log rafting is the loss of bark which commonly occurs when the logs are dumped into the water.

This report was submitted by the Food and Wood Products Branch, Corvallis Field Station, Industrial Environmental Research Laboratory-Cincinnati under the sponsorship of the Environmental Protection Agency. Work was completed as of June 1974.

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SECTION I
CONCLUSIONS

1. Dissolved oxygen in flow-through log ponds tends to become depleted during summer months when flows are low and the waters are warm.

2. Both biological and chemical aspects of water quality can be adversely affected by flow-through log ponds.

3. The discharge from flow-through log ponds is esthetically displeasing, due mainly to the dark color of the water. This dark color persists downstream until it is diluted out.

4. The runoff from wet decks has pollutional characteristics equal to or greater than that of waters from flow-through log ponds.

5. While wet deck runoff has the potential to degrade water quality in a receiving stream, especially under low flow conditions, this effect could not be directly demonstrated.

6. The effects of handling and rafting logs on water quality in rivers and sloughs depends on the intensity of such activity and the stream's flushing action. A signficant problem associated with water storage is the loss of bark during log dumping. Degradation will tend to be greater when larger amounts of logs are handled and rafted. Flushing action of the stream may reduce degradation, or even transfer the problem to another area.

SECTION II
RECOMMENDATIONS

Each situation is unique, but the following recommendations should be helpful in establishing guidelines for individual situations.

1. The use of flow-through type log ponds should be discouraged.
2. Where it is not practical to eliminate flow-through ponds certain minimum requirements should be met to protect downstream water quality.

    a. Downstream water uses should not be adversely affected by the discharge from the log pond.
    b. The log pond should not be located on a stream used for valuable fish production, especially migratory fish.
    c. Some method of aerating the discharge from the log pond should be provided. This might include the use of an aerator near the point of discharge, or having turbulent flow over the spillway.

3. When it is necessary to drain a log pond for cleaning, or repair, adequate precautions should be taken to protect downstream water quality. At many sites spray irrigation onto the land would possibly be a suitable means of disposing of the water. If spray irrigation is not feasible, then cleaning should take place during a period of high flow to minimize the impact on water quality.

4. Flow-through type log ponds should be cleaned periodically to remove accumulated bark and other organic debris. Precautions should be taken at all times to prevent floating debris from escaping.

5. Runoff from wet decks should not be discharged directly to the receiving water. Three possible ways of handling wet deck runoff are: collection and reuse of the runoff for sprinkling; spray irrigation if adequate land is available; containment in shallow basins to allow natural evaporation.

SECTION III
INTRODUCTION

The research[1] described in this report was intended to determine the effects of various methods of log handling and storage on quality of receiving waters. Both the biology and chemistry of the receiving waters were evaluated with emphasis on biology.

In many areas the supply of logs to processing mills may be seasonal due to climatic conditions, making it necessary to store logs in order to maintain production throughout the year. Rapid harvest of trees because of disease, forest fire damage, or other reasons may result in an excess of logs that must be stored until they can be processed. Fluctuations in the price of timber and market for lumber can likewise significantly influence the amount of logs in storage.

A major consideration in long-term storage of logs is maintenance of their quality. Checking, insect damage, and infestation by fungi are all of concern. If logs are allowed to dry out they tend to split, or check. In addition to decreasing the value of the logs, the checks offer entryway for attack by insects and fungi. In some parts of the country, severe checking may occur after only a few months of storage if preventive measures are not taken (Dobie 1965). The most common method of preventing or minimizing checking is keeping the logs wet.

McHugh et al. (1964) report that there are about 4,860 ha (12,000 ac) of log ponds and 800 ha (2,000 ac) of sloughs or canals used as log ponds in Oregon. In addition, there are about 1,620 ha (4,000 ac) of log ponds in Washington, 1,620 ha (4,000 ac) in northern California, and 400 ha (1,000 ac) in Idaho. The size of the ponds varied from less than a hectare to over 160 ha (400 ac). Water depths ranged from 1 to 9 meters.

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1. When this research was conducted, Gerald S. Schuytema was in the Laboratory Services Branch; he is now with the Eutrophication and Lake Restoration Branch of the Pacific Northwest Environmental Research Laboratory. Robert D. Shankland is now with the Enforcement Division, Denver Regional Office, EPA.

Prior to 1968 little work had been done on determining the influence of various log handling and storage practices on water quality. Probably the most extensive work on the subject up to then had been done by McHugh et al. (1964). Although the major emphasis of their study was directed toward mosquito problems associated with log ponds, water quality analyses were made on waters from over 80 ponds. In 1968 Oregon State University began extensive studies on the influences of log handling and storage practices of water quality. These studies, under the supervision of Dr. Frank Schaumburg, were financed in part by EPA Research Grant EPA-R2-73-085.

The chemistry of wood is complex, involving many different organic compounds. Browning (1963) grouped the constituents of wood into the following classifications: carbohydrates, phenolic substances, terpenes, aliphatic acids, alcohol, proteins, and inorganic substances. The relative amounts of the various compounds varies with such factors as the species and age of the wood. The carbohydrates consist mainly of polysaccharides, which include cellulose, hemicelluloses, starch, pectic substances, and arabinogalactans. Wood is approximately 75 percent polysaccharides, about three-quarters of which is cellulose. Wood is relatively insoluble (roughly one percent by weight) in cold water. The percentage entering solution increases with temperature, which is largely attributed to increased hydrolysis (Browning 1963).

The chemistry of bark differs somewhat from that of wood, with one of the differences being the amounts of extractives obtained (Browning, 1963). Generally bark has a higher percentage of material extractable in hot water than does wood. These include tannins, simple sugars, glycosides, polysaccharides, gums, and pectins.

Graham and Miller (1969) and Schaumburg (1970) found that significantly greater quantities of organics were leached from ponderosa pine logs than from Douglas-fir logs. This might be expected based on the relative amounts of hot water extractable material that have been reported for the two barks (Browning 1963);ponderosa pine 12.1 percent, Douglas-fir 2.3 percent. Schaumburg (1970) found bark to be the main source of color producing compounds leached from the logs, as measured by the Pearl-Benson Index (PBI).

McHugh, et al. (1964) made similar observations concerning bark as the main source of color producing compounds in log pond waters. Leaching rates were found to be concentration dependent,

with the rates tending to decrease as the concentration of organics in the holding water increase. In fresh flowing water the rate of leaching is likely to be relatively consistent for periods up to 80 days or more.

Ninety-six-hour bioassay studies (Schaumburg 1970) were conducted to determine the toxicity of leachates from Douglas-fir, hemlock, and ponderosa pine logs to chinook salmon and rainbow trout fry. There were no mortalities to trout fry in 100 percent solutions of leachate from ponderosa pine and older (120 years) Douglas-fir logs. Similarly, there were no mortalities to salmon fry in 100 percent solution of leachate from hemlock. Leachate from younger (50 years) Douglas-fir logs was somewhat toxic to salmon fry. The leachate from log segments without bark tended to be more toxic than the leachate from log segments with bark.

Oxygen uptake rates of benthic (bottom) deposits of bark were studied by Neal and preliminary results of part of his work have been reported (Schaumburg 1970). A specially designed benthic respirometer was used for in situ determinations of oxygen uptake rates in a fresh flowing stream storing ponderosa pine logs. In a control area, the oxygen uptake rate was 0.19 $gO_2/m^2/day$, while at three stations with bark, the rates ranged from 0.38 to 2.0 $g\ O_2/m^2/day$. The volatile solids content of the top 5.1 cm of the benthic deposits ranged from 8.1 to 86.5 kg/m^3. The oxygen uptake rate increased with increasing volatile solids content. Stein and Denison (1966) observed an in situ uptake rate of about 3.6 $gO_2/m^2/day$ for a cellulose sludge deposit as compared to 1.1 $gO_2/m^2/day$ for a sandy bottom. Based on laboratory studies of paper and a paperboard mill sludge, McKeown et al. (1968) concluded that the oxygen uptake rate does not increase at sludge depths greater than 0.3 m. They also concluded that the oxygen demand is increased by mixing or turbulence.

Schaumburg (1970) made hypothetical calculations on the bark loss, benthic oxygen uptake, and leached organics associated with ponderosa pine logs. He calculated that about 213,600 kg of bark (dry weight basis) would be dislodged from 37,100 m^3 of logs during unloading (vertical dumping) and 30 day raft storage. About 147,000 kg of the bark would have sunk by the end of the 30 day storage period. The benthic oxygen demand of 20 ha (50 ac) of sunken bark, was calculated to be 100.7 kg of O_2/day. A storage area of 20 ha (50 ac) hypothesized to be covered with logs for 30 days, was calculated to contribute daily a COD of 317 kg and a BOD of 145 kg. Chemical oxygen demand (COD) is a measure of the amount of oxygen needed to chemically oxidize most organic

compounds. Biochemical oxygen demand (BOD) is the quantity of oxygen used in the biochemical oxidation of organic matter at a specified time and temperature, normally 5 days and 20°C. The authors pointed out that the significance of the pollutants attributable to log rafts must be evaluated for each individual circumstance.

There are few specific studies on biological problems associated with log handling and storage practices in the Pacific Northwest. Numerous investigations have demonstrated the harmful effects of wood fiber discharged to a stream (Bartsch 1949, Bartsch 1960, Ellis 1943, Westfall 1946). The blanketing action of these fibers decreases productivity by smothering aquatic organisms and covering fish spawning beds. Decomposition of the matted fibers also uses up dissolved oxygen necessary to a desirable aquatic community, in addition to being unsightly.

Log storage debris and wood chips were among the wastes believed detrimental to the aquatic life of the Yaquina River and Bay, Oregon (USDI 1968). Bark and debris from log rafting were harmful to dungeness crab habitats in Hamilton Bay, Alaska (McHugh 1968). The crab were not found within areas heavily covered by bark but were abundant outside of these areas. Accumulated bark from stream driven pulpwood in New Brunswick, Canada, depleted dissolved oxygen to 12 to 65 percent below saturation (Wright 1963). These accumulations remain on the bottom for long periods and represent a constant danger to fish populations.

SIGNIFICANCE OF BIOLOGICAL STUDIES

The response of aquatic plants and animals to a polluted environment have been discussed by numerous authors (Hynes 1960, Ingram 1960, Keup 1960, Klein 1962, Mackenthun 1969). Elements of the biota that are commonly studied include the bottom dwelling animals, attached algae and slime organisms.

Bottom Dwelling Animals

The kinds and numbers of bottom-dwelling animals inhabiting a particular stream reflect the quality of water that has generally prevailed in the area for an extended period of time. Some of these animals are capable of withstanding polluted conditions, and increase rapidly in population when competition with other forms is eliminated. Examples of some animals which can

withstand organic pollution are sludgeworms, certain midge larvae, leeches and lung-breathing snails. As conditions suitable for these tolerant organisms develop, the more sensitive animals such as stoneflies, mayflies and caddisflies are removed from the community. Ultimately, a population consisting of large numbers of only one or two species can make up the fauna of a stream bottom. A bottom-dwelling population consisting of small numbers of a large variety of organisms is typical of the unpolluted habitat. Although some of the pollution tolerant forms would form part of such a community, they would be in the minority.

When a single species dominates the population to the exclusion of organisms intolerant of low dissolved oxygen and organically enriched water, the stream is considered severely degraded. However, even those animals which can tolerate such conditions require some oxygen, and streams may become so heavily loaded with oxygen depleting materials that no animals can exist. Toxic materials can also remove a population of bottom-dwelling animals although the habitat may be otherwise favorable.

A comparison of the biological community both upstream and downstream from a waste source thus provides a valuable clue to the condition of the bottom and the purity of the surrounding waters. However, since the bottom animal population inhabiting any particular area is dependent upon many factors, including the characteristics of the substrate, stream flow, currents, temperature, light and depth, comparisons are best made between similar habitats.

Attached Algae

Algae (non-vascular aquatic plants), like all green plants, require nutrients for growth. In addition to many trace elements, they take up measurable quantities of nitrogen and phosphorus. All other factors being favorable, the higher the concentration of these nutrients, the greater will be the density of algal growth.

Attached algae can cover all suitable substrata on the stream bottom and are a very important food source for many of the bottom-dwelling animals. Since these algal forms are stationary,

they reflect the quality of the water which has passed over them. Certain forms, such as some of the blue-green algae, are typical of organically enriched waters. Decreased water transparency can be detrimental to attached algae populations by removing necessary sunlight. This can occur in silt laden waters or by the introduction of highly colored wastes.

Slime Growths

Biological slimes, commonly represented by the filamentous bacterium Sphaerotilus, can be a problem in streams subjected to nutrient loading from a variety of waste materials. These growths, non-esthetic in appearance, can blanket the stream bed and render whole areas of a stream unsuitable for developing fish while destroying the habitats necessary for desirable bottom dwelling animals. Waste materials utilized by these slime growths include carbohydrates, sugars and nitrogen. Often these growths are more noticeable in winter since competition for the nutrients with the more cold sensitive forms is reduced.

SECTION IV
SELECTION OF STUDY SITES

Water and biological samples were collected from nine study sites. Five sites involved log rafting, two included flow-through log ponds, one included a flow-through log pond and a wet deck, and the other had a closed log pond (no discharge) with a wet deck (a wet deck is an on-land stack of logs that is generally kept wet in warm weather to prevent excessive drying and consequent checking). The individual sites are discussed in more detail in Section VI.

Several factors were considered in the selection of study sites. These included possible interference from other waste sources; excessive dilution by the receiving waters; suitable conditions for biological studies; and permission of the companies involved. Since one of the main project objectives was to determine the effects of log handling and storage on water quality, interference from other waste sources was to be at a minimum. This criterion tended to eliminate many sites from further consideration. Excessive dilution by the receiving waters was considered undesirable for the study of flow-through log ponds and the runoff from wet decks. Therefore, consideration was limited to sites on small streams where there was more likely to be a change in water quality.

SECTION V
METHODS OF SAMPLE COLLECTION AND ANALYSIS

WATER CHEMISTRY

Sample Collection and Preservation

All but two of the water samples for chemical analysis in our studies were grab samples. The method of collection varied; for all deep samples and some shallow samples either a Kemmerer sampler or a Van Dorn sampler was used. The remaining shallow samples were either collected in a bucket or by dipping the sample container into the water. Samples from the log rafting sites were collected near the stream bottom to better detect any possible effect from settled bark. Unstabilized samples were iced immediately and were in the laboratory within 24 hours after collection. Samples for COD and organic carbon analysis were preserved by adding 10 ml of concentrated sulfuric acid per liter of sample. Mercuric chloride, 10 ml saturated solution per liter of sample, was used to stabilize the samples for nitrogen and phosphorus analysis. In the laboratory all samples were stored at 5°C.

Field Analysis

Temperature, dissolved oxygen (DO), and some of the pH measurements were performed in the field. DO concentrations were determined by a DO meter or the Winkler-Azide titration method. McHugh, et al (1964) reported that the Winkler method appeared to give low results with log pond waters. A comparison was therefore made using a calibrated DO meter and the Winkler-Azide method to determine the DO concentrations in a sample of log pond water having a COD of 87 mg/l. With a full-strength sample at room temperature the Winkler-Azide method showed 7.9 mg/l of DO compared to 8.25 mg/l for the DO meter, or a difference of 0.3 mg/l. The difference became less as the sample was diluted with distilled water. At dilutions yielding COD concentrations of 32 mg/l and less, the differences were 0.1 mg/l or below, which was not considered signficant at the COD concentrations encountered in this study.

Laboratory Analyses

In the laboratory the number of analyses performed on each sample varied. The analyses for chemical oxygen demand (COD),

biochemical oxygen demand (BOD), pH, conductance, suspended solids (SS), volatile suspended solids (VSS), color and chlorides were performed according to Standard Methods (APHA 1965). The methods used for determining total organic carbon (TOC), orthophosphate, Kjeldahl nitrogen, nitrates, and turbidity are given in FWPCA Methods for Chemical Analysis of Water and Wastes (USDI 1969). The procedure described by Felicetta and McCarthy (1963) was used in determining Pearl Benson Index (PBI) concentrations. In this report PBI concentrations are reported in milligrams per liter (mg/l). One mg/l of PBI equals 10 ppm of 10 percent apparent spent sulfite liquor. This test, commonly used in the wood pulp industry, was used in this study to indicate the same type of reactive ligneous matter.

BIOLOGY

Biological field and laboratory methods were generally those prescribed by Standard Methods (APHA 1965), Limnological Methods (Welch 1948) and The Practice of Water Pollution Biology (Mackenthun 1969).

Bottom Dwelling Organisms

Bottom fauna stations in the log rafting areas were usually established at three points on a transect across the stream: Mid-stream and the two quarter points. In some cases, samples were collected only at certain points on either side. One Ponar grab sample was collected at each station. This sampler, enclosing an area of 538cm² (0.58 ft²) was well suited to the silty-sand and debris bottom types common in the rafting areas.

The streams were narrow and tended to have uniform bottom types at each transect at the log pond and wet deck study sites. Therefore, the three samples collected across the stream in these areas were considered sub-samples of the same station. They were designated as follows: A - right side facing downstream, B - mid-stream, and C - left side facing downstream. Only the two side samples were collected in very narrow streams. The Ekman grab sampler was used at most of the stations on Elk Creek and was more applicable to shallower, softer bottomed streams than the Ponar sampler. The Ekman enclosed an area of 232.26 cm² (0.25 ft²). The Surber square-foot sampler was used at the remainder of the study sites and was designed for shallow rock and gravel bottoms.

Non-quantitative bottom samples were collected where possible with a dip net or by overturning rocks or other materials at the shores. This supplemented data collected by the quantitative devices. The dredgings or bottom materials collected by the various sampling devices were washed through a U.S. Standard No. 30 sieve and were preserved in the field in a 10 percent formalin solution.

In the laboratory, the dredging were rinsed in a U.S. Standard No. 30 sieve,placed in trays, the bottom animals removed and preserved in 70 percent alcohol. Rose Bengal or phloxine B stain was frequently added to the samples before rinsing to facilitate the sorting process. The organisms were identified to genera when possible. Appropriate factors converted the counts per sample to numbers per square meter of stream bottom.

The identity and numbers per square meter of the bottom animals collected at each station are presented in the Appendix. The numbers were rounded to the nearest whole. The number of different genera determined for each bottom sample represents the minimum number of genera present. Certain forms such as worms or leeches were not identified beyond their broader classifications. Other forms, such as immature mayflies or stoneflies, could not be clearly identified beyond the family level. Unknown organisms and pupae were included in the total number of organisms but not tabulated as separate genera unless it was obvious they could not be mistaken for other forms.

The volume of bark and detrital material retained on the sieve from the log rafting area bottom samples was determined by displacement. After the benthic organisms had been removed, the material was drained on absorbent toweling for one minute and then placed in a graduated cylinder containing a known volume of water. The resulting displacement approximated the volume of material and was reported in cubic centimeters per Ponar grab sample.

Attached Algae and Slime Growths

Attached algae and slime growths were collected from rocks, logs and pilings and preserved in 3 percent formalin. Identification was conducted with a compound microscope at 450 to 1,000 magnifications. Samples of filamentous slime bacteria were stained with cotton-blue lactophenol before examination.

PHYSICAL OBSERVATIONS

Light penetration of the water was measured in a number of locations with a 20 cm Secchi disc. Observations of the water surface, stream bottom, water depth, shoreline, flow characteristics and attached growths were routinely recorded. Flow was measured at four of the study sites with either a Price type or a pygmy current meter.

SECTION VI
RESULTS

LOBSTER CREEK

Lobster Creek study site is located south of Alsea, Oregon. Here, there is a sawmill and limited log storage facilities. About 66,000-80,000 m^3 of logs are handled annually. Douglas-fir is the predominant species with some cedar and hemlock. These logs are hauled in by truck, stacked in a dry deck (no sprinkling), mechanically debarked, and placed in the log pond for temporary storage. Generally there are no more than a few days supply of logs in the pond.

The log pond is a flow-through type located on Meadow Creek, a small tributary of Lobster Creek. The pond covers approximately 1.2 ha, has an average depth of about 2 m,and a maximum depth of about 4.6 m. Normally only the downstream half is used for holding logs. If the flow of Meadow Creek is not adequate to maintain water levels in the log pond, additional water is added by pumping from Lobster Creek. This was not necessary during this study. It is approximately 0.3 km from the log pond spillway to the confluence with Lobster Creek.

Meadow Creek has a drainage area of approximately 3.9 km^2. Most of the area upstream from the log pond is forested while downstream there is a cattle pasture along a portion of the creek. Most of the Lobster Creek drainage is forested with some cattle pastures and hay fields in the relatively level valley areas. In the study area cattle had free access to Lobster Creek, which is a spawning area for silver and chinook salmon, steelhead, and cutthroat trout (OSWRB 1965).

A reconnaissance was made in March and more detailed sampling conducted in June and September 1969. There were two biological sampling stations on Meadow Creek and four on Lobster Creek (Fig. 1). The stream bed of Meadow Creek was not uniform throughout the study area. At station L-1 upstream from the log pond the bottom was composed of silty-sand and gravel as compared to predominately bedrock and cobbles at station L-4 near the mouth of Meadow Creek. At all four sampling stations on Lobster Creek the bottom material consisted mainly of rock, cobbles, and gravel. Water depths were relatively shallow in both June and September, not exceeding one-third meter (Table 1).

Station No.	Station Description
L-1	Meadow Creek about .6 km above log pond outlet works.
L-2	Log pond just above outlet works.
L-3	Meadow Creek about 15 meters below log pond outlet works.
L-4	Meadow Creek just above Lobster Creek.
L-5	Lobster Creek just above Meadow Creek.
L-6	West bank of Lobster Creek about 60 meters below Meadow Creek.
L-7	East bank of Lobster Creek about 60 meters below Meadow Creek.
L-8	Lobster Creek about 185 meters below Meadow Creek. At downstream end of pool.

Note: Not to scale.

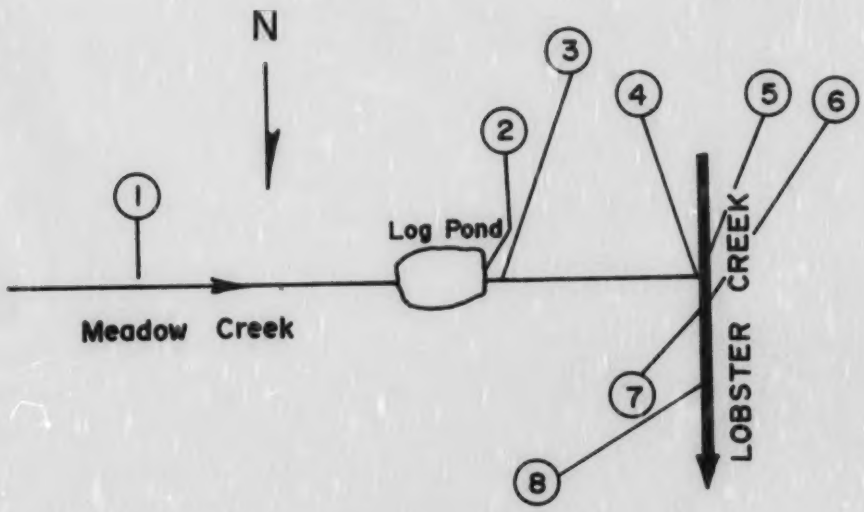

Figure 1. Lobster Creek study site

Table 1. LOBSTER CREEK STUDY SITE BOTTOM DWELLING ORGANISMS

Station	No. Samples	No. Genera	No./m^2	Depth (cm)	Bottom Type
June 11, 1969					
L-1	2[a]	20	1,731	15	Silty-sand, gravel
L-4	2[a]	17	1,285	15-30	Bedrock, cobbles
L-5A	1	11	217	15-30	Rock, cobbles, gravel
C	1	10	240	15-30	Rock, cobbles, gravel
L-6	1	17	304	15-30	Rock, cobbles, gravel
L-7	1	13	457	15-30	Rock, cobbles, gravel
September 3, 1969					
L-1[b]	1	16	-	15	Gravel
L-4	1	4	44	6-15	Bedrock, cobbles
L-5A	1	9	153	15	Rock, cobbles, gravel
C	1	11	691	15	Rock, cobbles, gravel
L-6	1	14	765	15-30	Rock, cobbles, gravel
L-7	1	11	1,055	15-30	Rock, cobbles, gravel
L-8[b]	1	16	-	15-30	Rock, cobbles, gravel

[a] Pooled data.
[b] Non-quantitative sample only.

Water quality was good upstream from the log pond in June and September (Table 2). Dissolved oxygen was high (9.0-10.2 mg/l) while COD (2-4 mg/l), suspended solids (1-2 mg/l), and turbidity (1-2 mg/l) were low. There were 20 genera of organisms in the quantitative sample collected in June and 16 genera in the non-quantitative samples taken in September. The high percentage (42%) of sludgeworms in the June samples was probably a reflection of the silty-sand bottom. Neither this material nor sludgeworms were evident in September. The predominant organisms in September were caddisfly larvae, mayfly nymphs, and midge larvae (App. A).

There was a sharp color contrast between the upper and lower ends of the log pond. The upstream end was greenish, indicative of algae and other aquatic plants; the downstream end where the logs are kept was dark. Transparency at the spillway (L-2) as measured with a Secchi disk, was 0.76 m in June and 0.23 m in September. Dissolved oxygen at L-2 ranged from 6.3 mg/l in March to zero in September. COD in the summer averaged about 15 times more at L-2 than upstream at L-1. PBI concentrations in June were 8 times higher at the spillway than at L-1 and were still 5 times higher downstream at the mouth of Meadow Creek. Increased waste loading from the logs, decreased flow in Meadow Creek and warmer summer temperatures all contributed to a lowering of water quality at the spillway.

Abundant growths of Sphaerotilus covered mayfly nymphs and gill-breathing snails near the mouth of the creek in March. Further upstream, about 46 m downstream from the log pond, stonefly and mayfly nymphs were similarly entangled. A coho salmon fry, estimated to have hatched the previous October or November, was captured at the same location. Water quality downstream from the pond in March was apparently good enough to support organisms commonly associated with clean water. However , the discharge from the log pond obviously contained sufficient nutrients to support the smothering growths of Sphaerotilus.

Only sparse amounts of Sphaerotilus were seen at the mouth of Meadow Creek in June, and none was observed in September. This reduction was probably due to increased water temperature. Abundant growths of the blue-green algae Oscillatoria, Phormidium and Lyngbya covered the stream bed at the mouth in September. Phormidium is associated with organically enriched waters, but less frequently than Oscillatoria.

The water was still dark at the mouth of Meadow Creek (L-4). In September the color intensity was 12 times that observed at L-1.

Table 2. LOBSTER CREEK STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Flow (l/sec)	Temp. (°C)	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3 (mg/l)
March 3, 1969															
L-2		6.3									17				
June 11, 1969															
L-1	12.74	12	10.2	7.0	62	2	2		2	2	2	1			
L-2		18	0.5	6.3	64	72	68		7	16	33	6			
L-4	15.29	17	8.5	7.0	69	8	8		6	11	15	3			
L-5	424.71	14	10.9	7.3	44	14	2		1	1	3	1			
L-6											1				
L-7											4				
September 3, 1969															
L-1	1.98	11	9.0	6.1	72	1	1	10	1	3	4	<1	.024	0.1	0.1
L-2			0	6.0							55				
L-3	1.27	19	2.4	6.2	95	56	28	200	18	2	35	2	.026	1.1	0.01
L-4	2.27	14	9.0	6.5	143	5	5	120	11	1	13	<1	.077	0.2	0.05
L-5	118.92	14	9.5	6.7	52	1	1	10	1	1	4	<1	.015	0.2	0.02
L-6											<1				
L-7											1				
L-8		14	9.6								<1				

Reaeration along the lower portion of Meadow Creek was good, giving DO concentrations at the mouth of 8.5 mg/l in June and 9.0 mg/l in September. Although the DO levels were high the bottom-dwelling animals were not indicative of clean water conditions. Seventeen genera were found in June. Of the total population of organisms 54 percent were fingernail clams, 29 percent midge larvae, and 13 percent sludgeworms. Fingernail clams are sometimes associated with degraded conditions and sludgeworms can tolerate many types of organic pollution. There were no caddisfly larvae or mayfly nymphs, and only one stonefly nymph was collected (App. A). Poor conditions continued into September. The increase in algal mats and lower streamflow at this time could have adversely decreased the available habitats. Only four genera of organisms were collected and were composed of only one stonefly nymph, two midge larvae, one beetle larva, and one blackfly larva (Table 1, App. A).

The flow from Meadow Creek tended to hug the east bank of Lobster Creek for the first 60-90 m. This was evident because of the darker color of Meadow Creek water. Stations L-6 and L-7 are near the west and east banks, respectively, of Lobster Creek and 60 m downstream from Meadow Creek. Station L-7 was influenced by Meadow Creek while L-6 was not. Downstream from L-6 and L-7 a long pool extends nearly to Station L-8. The flow of the two creeks apparently became mixed in this pool.

Water quality was generally good in Lobster Creek with the exception of some slight differences near the east bank just downstream from Meadow Creek. Dissolved oxygen was high (9.5-10.9 mg/l), the amount of oxidizable matter was low (COD < 1-4 mg/l), and the water was clear except where the flow of Meadow Creek hugged the east bank. Moderate amounts of Sphaerotilus covered the rocks on the right bank of Lobster Creek downstream from Meadow Creek in March. These growths were not present in June or September, probably as a result of higher water temperatures. There were slight differences between the bottom animal populations at stations L-6 and L-7. At L-7 there was a higher percentage of midge larvae in both June and September as compared to L-6. In September there were sludgeworms at L-7 but no mayfly nymphs, while at L-6 there were mayfly nymphs and no sludgeworms. These differences may have been due to a degrading effect by the flow of Meadow Creek. However, since the differences are slight, they also may have been partly related to natural variation in the distribution of the bottom dwelling animals.

Meadow Creek's lack of impact upon the biology of Lobster Creek was due largely to the relative sizes of the two streams. The

flow in Lobster Creek was 27 times that of Meadow Creek in June and over 52 times the flow in September (Table 2).

In summary, dissolved oxygen almost became depleted in the downstream end of the log pond during warm weather. There was sufficient carbon and other nutrients in the discharge from the pond to support abundant growths of Sphaerotilus in Meadow Creek when temperatures were low enough. The log pond water was esthetically objectionable in color and adversely affected the bottom organisms in Meadow Creek during the summer. There were only slight, localized effects on water quality in Lobster Creek because of dilution.

ELK CREEK

Elk Creek study site is west of Noti, Oregon, in the Long Tom River drainage, a sub-basin of the Willamette River. The log storage facilities consist of a flow-through log pond on Elk Creek. Logs brought in by truck are stored in the pond until needed, then hauled away. Storage varies from almost nothing to 3,500-4,700 m^3 of logs. An average of 5,900 m^3, predominantly Douglas-fir, pass through the pond annually.

The pond has a surface area of about 10 ha. The maximum depth in the stream channel is about 4.6 m; the upper end of the pond is shallow. Accumulated bark and dirt are removed periodically by dredging.

Average annual precipitation in the area is about 127-152 cm. Much of the Elk Creek drainage is forested, especially in the hilly areas. Upstream from the study area Elk Creek flows through open valleys used for cattle pasture and hay fields. There are also pastures and farm land about 1.3 km downstream from the pond. Cattle had free access to the creek near the sampling station located upstream from the log pond.

Biological and water chemistry samples were collected in October, 1968, and July, 1969 (Tables 3 and 4). One sampling station was established upstream from the pond and four downstream (Fig. 2). The stream bed was not uniform throughout the study site. Upstream from the pond at E-1 the bottom was sandy silt. Water depth was 0.61 m in October, 1968, but dropped to 0.15 m and less the next summer. Immediately downstream from the spillway the stream bed was rocky and contained several riffles at E-3. Within 0.2 km further downstream the stream gradient flattened

Table 3. ELK CREEK STUDY SITE BOTTOM DWELLING ORGANISMS

Station	No. Samples	No. Genera[a]	No./m^2[a]	Depth cm	Bottom Type
October 10, 1968					
E-1[b]	1	6	-	61	Sandy-silt
E-3	1	9	1,895	15-30	Rock, cobbles, gravel
E-4	4	7	733	30-61	Sandy-silt, bark, branches
E-5[b]	1	13	-	30-61	Sand, bark
July 23, 1969					
E-1	3	6	409	30	Sandy-silt
E-3[b]	1	9	-	30	Rock, cobbles
E-4	3	13	2,008	61-76	Sandy-silt, gravel, branches
E-5	3	17	1,434	30-61	Sandy-silt, bark, wood

a/ Pooled data.
b/ Non-quantitative sample only.

Table 4. ELK CREEK STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Flow (l/sec)	Temp. °C	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	TOC (mg/l)	BOD (mg/l)	Ortho-P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
October 18, 1968																
E-1		11	8.7									4				
E-2		11	10.6[b/]									7				
E-3		12	10.2													
July 23, 1969																
E-1	45.3	16	8.5	7.1	43	16	2	50	14	0.5	10	5		.013	0.4	0.3
E-2		18	0.4	6.2	47	4	3	50	3	2.4	14	4	3	.009	0.6	0.39
E-3		21	6.7								14	5				
E-4		22	6.4	6.8							13	5				
E-5	84.9	20	6.9	7.2	49	6	2	50	3	2.5	14	4	2	.009	0.4	0.48

b/ Average of 11.0 mg/l at 15 cm and 10.2 mg/l at 1.37 M depth.

out and the stream was somewhat slower flowing with shallow pools. The stream bed was sandy-silt at E-4, changing to silty sand and sand at E-5. Water depth ranged from 0.3 to 0.76 m at these two stations and varied little between seasons. Bark chunks, sunken logs, and branches were common at the lower two stations.

At station E-1 the water was clear while at the pond and downstream it was dark, a characteristic of log pond waters. Transparency (Secchi disk) just upstream from the spillway was limited to about 0.61 m at both seasons. The water was dark, foamy and displeasing in appearance as it cascaded over the rocks below the spillway. Somewhat contradictorily, samples collected from E-1, E-3, and E-5 in July had the same color intensity, 50 color units, as measured by the Platinum-Cobalt method. This apparent discrepancy can be partially explained. The Platinum-Cobalt method does not actually measure the color of a sample, but compares the transmission of light through the sample and through standard solutions of chloroplatinate. This method is not reliable with certain colors and possibly not with certain log pond waters. In July the water at E-1 was shallower than at stations E-2, E-4, and E-5. This could result in the water appearing to have less color than at the other stations.

Although the dissolved oxygen was nearly depleted (0.4 mg/l) just upstream from the spillway in July, reaeration of the water cascading over the spillway raised oxygen levels to over 6 mg/l. There was a slight increase in COD concentrations from upstream to downstream, from 10 to 14 mg/l. PBI concentrations in July were about five times higher downstream from the pond than they were upstream. The other chemical parameters studied varied little between up and downstream from the pond (Table 4).

Thick mats of an unidentified filamentous green algae covered the face of the spillway. Small amounts of Batrachospermum, a filamentous green alga common to colder water, were collected at E-1 and E-3 in July. The stream bed at E-1 was a favorable habitat to the sediment-associated midge and fly larvae and sludgeworms which predominated. A non-quantitative sample in October contained mostly horsefly and cranefly larvae and sludgeworms. The following July, midge larvae comprised 6 to 11 percent and sludgeworms from 8 to 20 percent of the bottom dwelling organisms collected in three sub-samples (App. B).

Normally, a habitat such as the riffle at E-3 would support diverse numbers of organisms. However, a sample from this location in October contained 84 percent sludgeworms and only 6

Station No.	Station Description
E-1	Elk Creek about 2 km (via highway) upstream from log pond spillway.
E-2	Log pond at spillway.
E-3	Elk Creek at riffles about 30 meters downstream of spillway.
E-4	Elk Creek at first bridge downstream (about .25 km) of log pond spillway.
E-5	Elk Creek at second bridge downstream (about 1.3 km of log pond spillway.

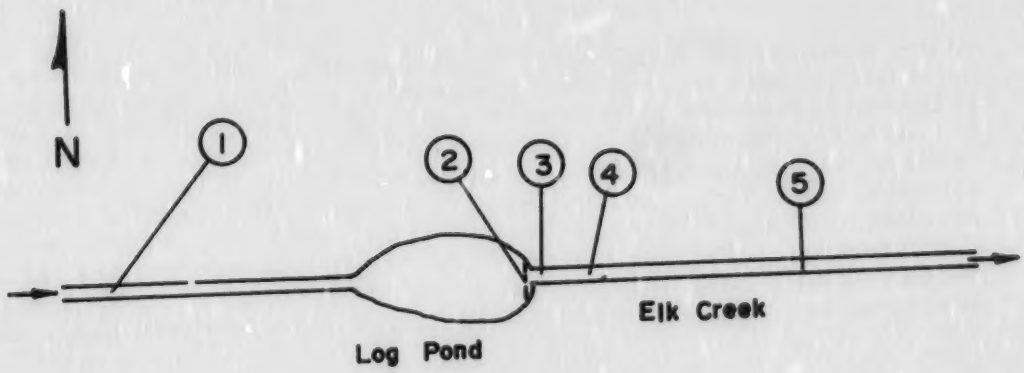

Figure 2. Elk Creek study site

out and the stream was somewhat slower flowing with shallow pools. The stream bed was sandy-silt at E-4, changing to silty sand and sand at E-5. Water depth ranged from 0.3 to 0.76 m at these two stations and varied little between seasons. Bark chunks, sunken logs, and branches were common at the lower two stations.

At station E-1 the water was clear while at the pond and downstream it was dark, a characteristic of log pond waters. Transparency (Secchi disk) just upstream from the spillway was limited to about 0.61 m at both seasons. The water was dark, foamy and displeasing in appearance as it cascaded over the rocks below the spillway. Somewhat contradictorily, samples collected from E-1, E-3, and E-5 in July had the same color intensity, 50 color units, as measured by the Platinum-Cobalt method. This apparent discrepancy can be partially explained. The Platinum-Cobalt method does not actually measure the color of a sample, but compares the transmission of light through the sample and through standard solutions of chloroplatinate. This method is not reliable with certain colors and possibly not with certain log pond waters. In July the water at E-1 was shallower than at stations E-2, E-4, and E-5. This could result in the water appearing to have less color than at the other stations.

Although the dissolved oxygen was nearly depleted (0.4 mg/l) just upstream from the spillway in July, reaeration of the water cascading over the spillway raised oxygen levels to over 6 mg/l. There was a slight increase in COD concentrations from upstream to downstream, from 10 to 14 mg/l. PBI concentrations in July were about five times higher downstream from the pond than they were upstream. The other chemical parameters studied varied little between up and downstream from the pond (Table 4).

Thick mats of an unidentified filamentous green algae covered the face of the spillway. Small amounts of Batrachospermum, a filamentous green alga common to colder water, were collected at E-1 and E-3 in July. The stream bed at E-1 was a favorable habitat to the sediment-associated midge and fly larvae and sludgeworms which predominated. A non-quantitative sample in October contained mostly horsefly and cranefly larvae and sludgeworms. The following July, midge larvae comprised 6 to 11 percent and sludgeworms from 8 to 20 percent of the bottom dwelling organisms collected in three sub-samples (App. B).

Normally, a habitat such as the riffle at E-3 would support diverse numbers of organisms. However, a sample from this location in October contained 84 percent sludgeworms and only 6

percent mayfly nymphs. The following July, a non-quantitative sample at the same location contained about half midge larvae and half mayfly nymphs (App. B).

A similar situation was seen at E-4. Sludgeworms comprised over 80 percent and midge larvae over 10 percent of the bottom-dwelling organisms in October. The next July, mayfly nymphs made up 40 percent of the organisms and sludgeworms only 35 percent (App. B). The lack of variety at these two stations in October follwed by increased diversity in July may have been due as well to a decrease in organic sediment as with seasonal fluctuations in the mayfly populations.

The best water quality, as reflected by clean water-associated organisms, was exhibited at E-5. Two genera of stonefly nymphs and five genera of mayfly nymphs were evident in non-quantitative sampling in October. Quantitative sampling the following July revealed the bottom organisms to be made up of 42 percent mayfly nymphs and 28 percent midge larvae. Sludgeworms composed an insignifcant part of the population at both seasons. Seven different genera were collected in non-quantitative samples in addition to seventeen genera collected in the grab samples in July (App. B).

The frequently encountered bark chunks and logging debris downstream from the pond could be damaging to the stream if present in sufficient amounts. The increase in desirable bottom-dwelling organisms downstream from the pond, however, can partly be attributed to increased numbers of habitats being made available in the bark and tree debris. Biologically, the log pond did not appear to have a very degrading effect upon the stream. Esthetically, there was definite degradation.

ROW RIVER

Row River study site is at Culp Creek, Oregon, and includes a sawmill and plywood plant near a portion of the Row River and Culp Creek. Logs are trucked to the site and those not used immediately are stored in wet decks.

Some logs are then taken to the pond, removed for debarking, and replaced temporarily. Some unbarked logs are also stored there. About 118,000-142,000 m^3 of logs are handled annually, predominantly Douglas-fir with some cedar and hemlock.

The log pond is a flow-through type on Culp Creek (Fig. 3). The dam at the downstream end of the pond is about 46 m upstream from the confluence with the Row River. Surface area of the pond is about 2.5 ha. The wet decking area is located adjacent to a bend in the Row River. Water for sprinking the cold decks in the summer is obtained by pumping from the river near station R-3. There were about 7,000 m^3 of logs in the wet decks in August, 1969. A drainage ditch runs along the southern edge of the wet decking area and receives seepage from nearby springs, glue wastes from the plywood plant, and part of the runoff from the wet decks. The wastes from the plywood plant did not appear to interfere with the study.

Most of the drainage area upstream from the study site is forested. Average annual precipitation in the area is about 127-152 cm (OSWRB 1961). At the U.S. Geological gauging station about 5 km downstream from Culp Creek the mean annual yield of the Row River over a 33 year period was about 526.76 x 10^6 m^3. The minimum recorded flow at this point was 0.28 m^3 per second.

Two biological stations on Culp Creek and five on the Row River were sampled in June and August, 1969 (Figure 3). At R-1, upstream from the log pond, the bed of Culp Creek was composed of cobbles, gravel, and sand. Downstream, bedrock predominated from the dam to the confluence with the Row River. The creek was shallow; water depth was 15 cm at R-1 and 3-15 cm at R-2. The stream bed of the Row River at R-3, upstream from Culp Creek, was composed of bedrock, rock and a few cobbles. The bottom materials were smaller in size at the downstream locations and were predominated by cobbles and gravel. The downstream sites tended to be more pool-like while the upstream location was characterized by swifter and more turbulent flows. Depths at the upper stations ranged from 15-60 cm, while the downstream stations were 30-60 cm deep.

The water was dark and foamy as it discharged from the log pond at R-2. Transparency in the pond, as measured with a Secchi disc, was 0.53 m in June and 0.61 m in August. In contrast, the water was clear at the upstream station. Color was substantially higher downstream from the pond, a four-fold increase in June and a 16-fold increase in August. COD was six to seven times higher (4-30 mg/l) at R-2 as compared with R-1. While the PBI was seven times higher at the downstream location in June, the two stations had about the same values in August. Dissolved oxygen, although very low in the pond at the dam (1.1 mg/l) increased substantially (7-8.5 mg/l) through reaeration over the spillway (Table 5).

Station No.	Station Description
R-1	Culp Creek about .56 km above log pond.
R-2	Culp Creek above confluence with Row River.
R-3	Row River about .24 km above Culp Creek.
R-4	Row River about .64 km below Culp Creek.
R-5	Runoff from north side of cold decking area. Flows into Row River.
R-6	Row River above drainage ditch. About 1.4 km below Culp Creek.
R-7	Drainage ditch above confluence with Row River.
R-8	Row River about 1.2 km below drainage ditch.
Stations not shown	
R-9	Water applied to last bay at west end of cold decking area. Sample collected from leak in pipe.
R-10	Composite sample of drippings from logs in 1st bay at western end of cold decking area.

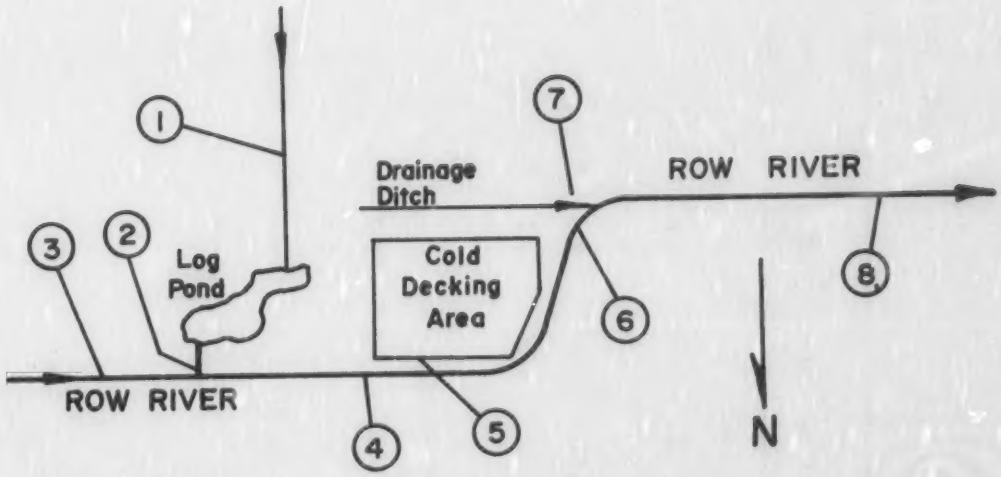

Figure 3. Row River study site

Table 5. ROW RIVER STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Flow (l/sec)	Temp. °C	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
June 18, 1969															
R-1	39.6	14	9.8	7.6		6	5	10	7	2	4	1			
R-2		22	8.5	7.6		7	5	40	10	15	25	3			
R-3	3454.3	20	8.9	7.1		2	2	5	3	1	4	1			
R-4		21	8.7	7.9		2	2	5	3	1	6	1			
R-7											151				
August 28, 1969															
R-1	5.7	13	10.0	6.6	80	4	2	5	2	2	4		.009	0.1	.02
R-2		22	7.4	6.3	88	11	11	80	4	3	30	4	.01	0.5	<.01
R-3	707.9	18	9.6	6.3	80	1	1	5	<1	< 1	4		.007	0.3	.02
R-4		19	9.4	6.5	80	2	1	5	1	<1	5				
R-5					125	8	<1	80	7	2	43	3	.011	0.6	<.01
R-6			9.7	7.1							6				
R-7				6.9	170	108	30	200	27	103	153	14	.049	1.4	.03
R-8											7				
R-9					87	1	1	5	1	<1	4				
R-10					50	4	4	80	2	5	40	5	.056	0.4	<.01

Nostoc, a filamentous blue-green alga common in shallow water, was sparse at R-1 in June. At the same time at R-2, abundant mats of the blue-green alga Anabaena covered the rock downstream from the dam. This alga is frequently associated with organically enriched waters.

Large amounts of Mougeotia, a common green filamentous alga, were growing at R-1 in August. The stream bed downstream from the dam at this time was abundantly covered with deteriorating mats of this alga. Oscillatoria, a filamentous blue-green alga frequently in organically enriched waters, was present in large amounts in these mats. No Sphaerotilus was collected from Culp Creek.

There was a dramatic reduction in the number of genera of bottom-dwelling animals at R-2 as compared with R-1 at both seasons. In June, the genera decreased from 15 to 3, while in August, the number decreased from 26 to 1 (Table 6).

The upstream station, R-1, was characterized by organisms commonly associated with good water quality conditions. In June, the bottom- dwelling animals were comprised of 43 percent caddisfly larvae, 17 percent mayfly nymphs, and 15 percent stonefly nymphs. In August, continued good conditions were indicated by 43 percent stonefly nymphs, 22 percent mayfly nymphs, and 6 percent caddisfly larvae (App. C).

Downstream from the pond at R-2 in June only a few cranefly larvae, mayfly nymphs, and gill-breathing snails were present. In August, only the gill-breathing snails remained (App. C).

There can be no doubt that the log pond had a degrading effect upon the bottom dwelling animals of Culp Creek. Even though a different bottom type downstream from the pond reduced the number of habitats available for desirable organisms, a greater variety of animals would have been expected than was found. Higher temperatures at R-2 as compared to downstream (22.5°C and 13°C) were also a probable cause of the decreased diversity. Esthetically, the creek was degraded and presented an unpleasant scene downstream from the log pond.

The runoff from the wet decks in August was similar in quality to the log pond waters. A composite sample (R-10) of drippings from logs in one of the wet decks had a BOD of 5 mg/l and a COD of 40 mg/l. Part of the sprinkling runoff flowed in small rivulets

Table 6. ROW RIVER STUDY SITE BOTTOM DWELLING ORGANISMS

Station	No. Samples	No. Genera[a]	No./m^2	Depth cm	Bottom Type
June 18, 1969					
R-1	2	15	480	15	Cobbles, gravel, sand
R-2	1[b]	3	-	3-15	Bedrock
R-3	1[b]	8	-	15-60	Bedrock, rock, cobbles
R-4	3	9	83	30-60	Cobbles, gravel
R-6	1	8	325	30-60	Rock, gravel
August 28, 1969					
R-1	2	26	1,138	6-15	Cobbles, gravel
R-2	1[b]	1	-	3-15	Bedrock
R-3	2	20	755	15-30	Bedrock, rock, cobbles
R-4	3	13	288	30-60	Cobbles, gravel
R-6	3	13	826	30	Cobbles, gravel
R-8	3	13	1,015	30	Cobbles, gravel

a/ Pooled data
b/ Non-quantitative sample only

down the bank into the river. A sample from one of these rivulets (R-5) had a BOD of 3 mg/l, COD of 43 mg/l, and a color intensity of 80 color units. A large portion of the surface runoff appeared to flow into the drainage ditch along the southern edge of the wet decking area. Since this ditch also received glue wastes from the plywood plant, the data from station R-7 cannot be used in characterizing the quality of wet deck runoff. The amount of water applied to the wet decks was not measured and it was not feasible to measure the surface runoff. Seepage along the river bank adjacent to the wet decking area indicated that some water was seeping into the ground and flowing laterally toward the river.

The water in the Row River was generally clear at all locations. The flow from Culp Creek, while dark and displeasing, soon dissipated in midstream.

Culp Creek had little measurable influence upon the chemistry of the Row River. There was almost no difference in the levels of chemical constituents up and downstream from the confluence of the two streams. Dissolved oxygen remained high (8.7-9.8 mg/l) throughout the river (Table 5).

No Spaerotilus was collected from the Row River. Moderate amounts of Stigeoclonium, a green filamentous alga, and Phormidium, a filamentous blue-green alga were present at R-3 in June. In August, the Phormidium, sometimes associated with organically enriched waters, became very abundant. Sparse amounts of a filamentous blue-green alga of the family Rivulariaceae were also present. This latter form is often found on rocks in flowing water and is not generally associated with enriched conditions.

Rivulariaceae were the predominant attached algae at stations downstream from Culp Creek during both seasons with one exception. In August at R-6, Mougeotia, a green alga, occurred abundantly along with sparse amounts of Spirogyra, a green filamentous form, and Anabaena, a blue-green form.

There was a substantial difference in the bottom-dwelling animal populations up and downstream from Culp Creek. Station R-3 was characterized by a variety of caddisfly larvae and mayfly nymphs at both seasons. In August, however, the downstream locations were predominated by large numbers of gill-breathing snails.

Non-quantitative sampling at R-3 in June revealed three genera each of caddisfly larvae and mayfly nymphs. In August, quantitative sampling showed the bottom-dwelling animals to be comprised of 34 percent mayfly nymphs and 20 percent caddisfly larvae. Twenty different genera were collected in August (App. C, Table 6). Good quality conditions prevaled during both seasons.

Degraded biological conditions were not evident in the Row River at the confluence with Culp Creek. In June, a variety of caddisfly larvae and mayfly and stonefly nymphs were collected in the Row in areas strongly subjected to Culp Creek water. The same conditions were evident in August.

In June, caddisfly larvae comprised 62 percent of the bottom-dwelling animals at R-4. Six different genera were collected through non-quantitative sampling in addition to nine different genera in the quantitative samples. In August, 13 genera were collected in the quantative samples but 57 percent of the organisms were gill-breathing snails generally associated with clean water conditions. Mayfly nymphs comprised only 10 percent of the organisms and riffle beetles made up 14 percent (Table 6, App. C). Station R-6 had over 76 percent mayfly nymphs in June and over 80 percent gill-breathing snails in August. The number of genera increased from 8 in June to 13 in August (Table 6, App. C).

The bottom-dwelling animal populations downstream from Culp Creek were not well balanced in variety as at the upstream station. In June, the downstream stations were characterized by high proportions of caddisfly larvae or mayfly nymphs. In general, the stream bed downstream seemed to have less attached algae and diatoms which could be used for a food supply. The smaller bottom materials could also have reduced the number of available habitats needed for a greater variety of organisms.

The shading caused by increased stream cover at the downstream sites may have decreased the amount of available sunlight needed for attached algae and diatom production and hence resulted in less food and subsequently less variety of organisms. It has been shown, however, that this type of gill-breathing snail and not reduced light can almost totally eliminate the attached growths in woodland streams west of the Cascades (Phinney 1969). This may have been the case in the Row River. The caddisfly larvae and mayfly nymphs may have not been as successful as the snails in competing for the available food supply in the downstream reaches of the study site.

Although there were profound changes in the bottom-dwelling fauna up and down stream from the confluence with Culp Creek, it is doubtful if they can be attributed to log handling and storage practices. The flow in the Row River was 87 times that of Culp Creek in June and 125 times the flow in September (Table 5). This certainly was a major factor in the lack of impact of the smaller stream upon the larger. There was no detectable effect from the wet deck and the plywood glue waste discharge. Changes in stream morphology coupled with natural changes in the bottom populations are a more likely explanation of the differences between the control station and the downstream stations. The most serious problem in the Row River is probably one of esthetics.

MIDDLE FORK OF THE JOHN DAY RIVER STUDY SITE

This site is at Bates, Oregon, and includes a portion of the Middle Fork of the John Day River and the mouth of Clear Creek, a tributary stream. Logs are hauled in by truck to a sawmill and those not used immediately are stored in wet decks. A closed pond adjacent to the sawmill contains logs taken from the wet decks in addition to some held in reserve. Approximately 50 percent of the logs used are pine, the remainder being white fir, Douglas-fir, and larch.

The log pond is located on the south bank immediately adjacent to the river. Although there is no direct discharge from the pond, some seepage undoubtedly reaches the river. When necessary, the water is pumped from the river to maintain the pond level. The two wet decking areas are located along the north bank of the river, one upstream and the other downstream from the pond. Water for these decks is pumped from the river just upstream from the pond. Only the upstream deck, which was not being sprinkled was in existance in May, 1969. The two decks were present in August however, both being sprinkled. The upstream wet deck was about 180 m long, contained about 4,700 m^3 of logs (about 85 percent pine) and was being sprinkled its entire length. About 120 m of this deck was within 5-10 m of the river's edge. The water became impounded at the base of the wet deck before flowing down the bank in small rivulets. The downstream wet deck, about 90 m long, contained about 85 percent pine and was under construction. This wet deck was located at the edge of the river bank and about 75 percent of its length was being sprinkled. Although the bank was moist, there were no signs of direct runoff. The amount of water applied to the wet decks was not measured as it was not feasible to measure the runoff.

Cattle had free access to the river in pastures both up and downstream from Bates (estimated 1969 population of 300). Domestic wastewater from the homes and sanitary wastewater from the sawmill were treated in septic tanks. Apparent drainage from these systems entered the river at a culvert opposite the upstream wet deck and another culvert just upstream from the lower wet deck. Children also mentioned septic tank seepage along the south bank just downstream from Clear Creek.

Bates is approximately 15 km downstream from the headwaters of the Middle Fork of the John Day River. The river elevation at the town is about 1,220 meters. Most of the drainage area upstream from the study site is forested. Average annual precipitation is between 50 and 76 cm. Downstream from Bates approximately 39 km of the river are used as spring chinook spawning grounds. Numerous tributary streams, including Clear Creek, are used by spawning steelhead trout (OSWRB 1962).

In August four samples were collected to determine the pollutional characteristics of the wet deck runoff (Table 7). These consisted of water applied to the wet deck (J-15), a composite of log drippings (J-16), and runoff (J-3 and J-5). The two runoff samples averaged 30 mg/l of BOD, 99 mg/l of COD, and a color intensity of 170 color units (Table 8). These are significant increases over the concentrations in the water applied to the logs. The runoff samples had higher COD and color concentrations than did the drippings from the logs. This difference is attributed to contact with bark debris in the ponded water at the base of the wet deck. The BOD to COD ratio, 0.3, indicates that there is a higher percentage of readily biodegradable organic material than is found in many log pond waters. The BOD, COD, and color concentrations in the runoff here were higher than in the runoff from the wet decks at the Row River study site probably because the logs at Bates had been sprinkled for only two weeks and they were predominately pine compared to mainly fir at the Row River site.

Four of the stations, J-2, J-9, J-10, and J-13, were sampled for biological samples in May, 1969, before wet decking had started. These, in addition to J-1 and J-14, were also sampled in August, 1969, after approximately two weeks of sprinkling. A station established in Clear Creek near its mouth was sampled during both seasons (Fig. 4, Table 7).

The bottom materials were generally similar throughout the study site (Table 9). Rock, cobbles, and gravel predominated at the four biological stations downstream from Clear Creek. Somewhat

Table 7. SAMPLING STATIONS MIDDLE FORK JOHN DAY RIVER STUDY SITE

Station No.	Road[a/] (km)	Station Description
J-1	0.0	MFJDR[b/] at bridge above upper pasture.
J-2	.97	MFJDR just above 1st cold deck.
J-3	1.03	Runoff from sprinkling of 1st cold deck. At upper end of cold deck.
J-4	1.05	Clear Creek at confluence with MFJDR
J-5	1.16	Runoff from lower end of 1st cold deck.
J-6	1.21	Culvert discharging to MFJDR. Located on south bank across from downstream end of 1st cold deck.
J-7	1.22	South bank MFJDR just above 1st bridge below 1st cold deck.
J-8	1.24	North bank MFJDR list below 1st bridge below 1st cold deck.
J-9	1.34	MFJDR at pump house.
J-10	1.72	Culvert discharging to MFJDR. Located on south bank just upstream from 2nd cold deck and downstream from J-10.
J-12	1.93	MFJDR just downstream from 2nd cold deck.
J-13	2.9	MFJDR about .97 km below 2nd cold deck.
J-14	5.79	MFJDR about 3.86 km below 2nd cold deck.
Stations not shown		
J-15	---	Water applied to 1st cold deck. Sample collected from 1st sprinkler.
J-16	---	Composite sample of drippings collected from logs in 1st cold deck.

a/ Gives approximate distance in kilometers below furtherest upstream station. Taken from road paralleling the river. Meant to show relative position of stations.
b/ Middle Fork John Day River.

Table 8. MIDDLE FORK JOHN DAY RIVER STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Flow (l/sec)	Temp. °C	DO (mg/l)	pH	Cond. umho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
May 26-27, 1969															
J-2			8.9		91	11	3	40	12	<1	12				
J-8	1698.8	14	8.8		69	14	3	20	10	<1	12				
J-10											12				
August 18-19, 1969 Temp & DO readings taken on August. 18. Samples collected on August 19.															
J-1											9				
J-2	113.3	21	7.1	6.7	148	1.8	1.6	35	1	<1	14	2	.06	0.4	.001
J-3				6.6	146	1	<1	200	3	12	84	22			
J-4	90.6	21	7.6	6.9	99	3.6	2	10	2	1	4	1	.05	0.2	.01
J-5				6.7	138	14	12	140	3	20	113	37			
J-6											27		.1		
J-7											8				
J-8	198.2		6.6		134	2.4	2	40	2	<1	12	1			
J-9											10				
J-10		22	7.6	6.9	129	2.4	2	35	1	<1	9	1	.08	0.4	.003
J-11											55				
J-12											15		.1		
J-13		22	7.0	6.7	126	3.2	2	40	2	2	14	2	.11	0.8	<.001
J-14				7.1	133	2	2	45	1	1	13	1	.08	0.4	<.001
J-15				7.3	119	5.4	0.9	35	3	<1	10	1	.07	0.5	.004
J-16				7.1	126	12	12	70	3	12	65	27	.18	0.8	<.001

Table 9. MIDDLE FORK OF THE JOHN DAY STUDY SITE BOTTOM DWELLING ORGANISMS

Station	No. Samples	No. Genera[a]	No./m^2 [a]	Depth cm	Bottom Type
May 26, 1969					
J-2	2	24	1,852	15-30	Cobbles, gravel
J-4[b]	2	12	403	30-60	Cobbles, gravel
J-9	1	15	638	30	Rock, cobbles, gravel
J-10	3	16	757	30-60	Rock, cobbles, gravel
J-13	2	23	1,323	30-60	Rock, cobbles, gravel
August 18, 1969					
J-1	2	23	3,663	15	Gravel, silty-sand
J-2	2	22	1,718	15	Cobbles, gravel
J-4[b]	2	39	4,112	15	Gravel
J-9	2	21	622	30	Rock, cobbles, gravel
J-10	2	28	1,227	15	Rock, cobbles, gravel
J-13	2	30	3,753	15	Rock, cobbles, gravel
J-14	2	31	4,686	15	Rock, cobbles, gravel

[a] Pooled data.
[b] Clear Creek.

NOTE: Not to scale.

Some tributary streams below 2nd cold deck are not shown.

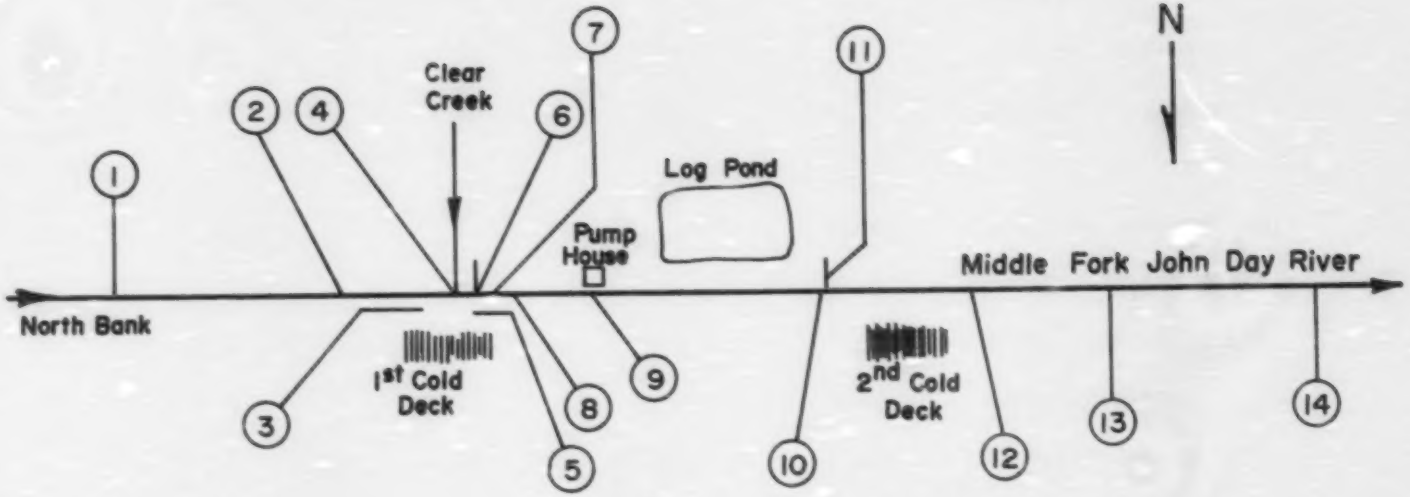

Figure 4. Middle Fork John Day River site

smaller materials were found upstream from this point with cobbles and gravel at J-2 and gravel and silty-sand at J-1. Cobbles and gravel were common at the Clear Creek station.

The river was shallow; in May, most locations were 30 to 60 cm deep, while in August most were 15 cm. The water was clear and the bottom visible at all stations on the two streams in both spring and summer.

There were other waste sources in addition to runoff from the upstream and downstream wet decks. Cattle were pastured between the following stations: J-1 and J-2, J-12 and J-13, and J-13 and J-14. They had access to the river in these areas and used it as their water supply. Septic tank seepage may have begun reaching the river just downstream from Clear Creek in addition to septic tank drainage from culverts at J-6 and J-11 (Fig. 4).

Dissolved oxygen in August was sufficiently high to support aquatic life throughout the study area (6.6-7.6 mg/l). Nitrogen and phosphorus levels were low; there were little differences upstream from the upper wet deck and the farthest two stations downstream (NO_3-N from 0.001 to <0.001 mg/l, ortho-P from 0.06 to .0.08-0.11 mg/l, and TKN from 0.4 to 0.4-0.8 mg/l). Chemical oxygen demand increased from 9 mg/l at station J-1 to 14 mg/l at J-2, possibly influenced by the cattle pasture between these two stations. The COD was lower at J-9 and J-10 (9-12 mg/l), possibly diluted by Clear Creek. The values at J-13 and J-14 were higher and comparable to those at J-2, perhaps influenced by the downstream wet deck, the culvert at J-11, and the two downstream cattle pastures. Clear Creek was characterized by generally lower levels of chemical constitutents than the Middle Fork of the John Day River (Table 8).

No Sphaerotilus growths were observed in the Middle Fork of the John Day River in May. Rannunculus, a submerged rooted aquatic plant, grew in small amounts at the majority of stations. Attached algae on the stream bottom increased from up to downstream, possibly as a result of additions of nutrients. No growths were observed at J-2, while there were moderate amounts of the green algae Tetraspora and Palmodictyon at J-9 and J-10. The green algae Cladophora and Stigeoclonium grew in abundance at J-13 along with lesser amounts of two common blue-green forms, Nostoc and Plectonema. Large amounts of the latter two types of green algae are often associated with enriched waters.

Rannunculus was abundant at J-1 in August and decreased downstream until there was none at J-14. Attached algae was much more abundant, both in variety and amount, in August than in May. The amount increased from J-1 to J-13 and then decreased at J-14.

The green algae Chaetophora and attached diatoms sparsely covered the rocks at J-1 and J-2 in August. At J-9, probably in response to wet deck runoff and septic tank wastes, moderate amounts of Sphaerotilus and abundant growths of the blue-green algae Phormidium and Anabaena covered the rocks. These blue-green forms are often associated with organically enriched waters. Farther downstream at J-10 Sphaerotilus increased and blue-green algae, mostly Phormidium and Oscillatoria, were abundant. Spirogyra, a green alga, became more apparent at this station. Large amounts of Sphaerotilus were growing directly downstream from the culvert at J-11. Station J-12, downstream from both this point and the downstream wet deck, was characterized by abundant Sphaerotilus intertwined with the green algae Spirogyra and Mougeotia. The Sphaerotilus growths then decreased at J-13 and were not observed at J-14. The attached algae at this station, the farthest downstream, was made up largely of moderate amounts of diatoms and Spirogyra.

The increased growth of attached algae and Sphaerotilus in the downstream reaches of the study area was no doubt a response to added nutrients or wastes. Although the chemical constituents varied little from upstream to downstream, they represent only the levels at the particular time the samples were collected. The attached algae however, reflect what has passed over them for an extended period of time. In addition, from the data available it would be impossible to attribute changes in the attached growths solely to wet deck runoff, septic tank drainage or cattle wastes.

Good water quality conditions, as indicated by the bottom dwelling animals prevailed in Clear Creek at station J-4 (Table 9, App. D). In May, the bottom population contained 50 percent mayfly nymphs, over 28 percent caddisfly larvae and only 10 percent sludgeworms. A 9-fold increase in the numbers of organisms from May to August, and an increase in the number of different genera from 12 to 39 between these two seasons, indicated both increased productivity and variety. The bottom animals at the later season were made up of 29 percent mayfly nymphs, 24 midge larvae, 5 percent stonefly nymphs, and 26 percent sludgeworms.

Fifteen to 24 different genera were collected quantitatively at each of the four stations sampled on the Middle Fork of the John Day River in May (Table 9, App. D). Non-quantitative samples at the same locations contained from 5 to 10 additionally different genera, indicating more variety. Although the bottom-dwelling animals indicated generally good water quality in May there appeared to be localized responses to possible waste sources.

Sludgeworms predominated at J-2, compromising 43 percent of the population. The remainder of the population contained 34 percent mayfly nymphs, 14 percent midge larvae and 1 percent caddisfly larvae. The rather high percentage of sludgeworms may have been a response to the cattle pasture just upstream.

Mayfly nymphs increased to 50 percent of the population and caddisfly larvae to 16 percent while sludgeworms decreased to 13 percent at the next station downstream, J-9. These improved conditions may have been partly a response to slightly different physical conditions. The bottom was rockier than upstream and because of the higher water at this season, the current was swifter and the water more turbulent than at the other stations. Since conditions here were slightly atypical of the rest of the stream at this time, only one sample was collected.

Generally good water quality, as indicated by the bottom-dwelling organisms, characterized the river in August (Table 9, App. D). Productivity and variety had increased from May to August, shown by an average increase per station of six genera and 1,400 organisms /m^2. The number of different genera increased as the stream progressed downstream. Twenty-one to 23 genera were collected at stations J-1, J-2, and J-9 while from 28 to 31 genera were collected at stations J-10, J-13, and J-14. The number of additional genera collected in non-quantitative sampling at each of these locations ranged from four to 11. The populations of bottom-dwelling organisms very likely increased in August since the attached algal growths at that time represented an abundantly available food source.

Riffle beetles were the predominant organisms at the first three biological sampling stations. These organisms may be scarce in streams with low dissolved oxygen and high sediment load. They comprised from 27 to 37 percent of the bottom organsisms at J-1, J-2, and J-9. Mayfly nymphs predominated at the last three stations, comprising 38 to 40 percent of the populations at J-10, J-13, and J-14.

Station J-1 was sampled in August in order to detect any possible effects from the cattle pasture upstream from J-2. There was little difference in quality between these two stations. Mayfly nymphs decreased from 27 percent at J-2 to 10 percent at J-9 while midge larvae increased from 5 to 31 percent between these two stations. This may have been a localized response to a combination of the upstream wet deck, the culvert at J-6, and the flow from Clear Creek.

A two week period of wet decking in August did not appear to have a deleterious effect upon the bottom-dwelling animals of this section of the Middle Fork of the John Day River. Localized changes in the bottom populations were evident in both May, when no sprinkling occurred, and later in August. The presence of nearby cattle pastures and septic tank drainage may have contributed to these changes and made a separation of the effects of wet decking impossible. Increased algal productivity in August, probably in part a response to the pastures and septic tank drainage, may have allowed the bottom animal population to increase in the downstream reaches. Esthetically, the presence of Sphaerotilus growths in August, which could not be attributed solely to wet decking, was a minor problem. Seriously degraded conditions could happen in this section of river should an extended period of wet decking occur at a time of low river flow, especially if there was no dilution by Clear Creek.

STEAMBOAT SLOUGH STUDY SITE

Steamboat Slough study site is on the north side of the Columbia River about four miles downstream from Cathlamet, Washington. The slough, approximately 3.2 km long and 90-122 m wide along most of its length, has a fairly good flow of water. Both ends of the slough open into a main channel of the Columbia River. The study site is used for intermittent temporary storage of log rafts. These rafts may be either spill-over from a nearby log handling operation or in transit on the Columbia River. No data were readily available on the amount of recent storage in the area.

Nine stations were sampled in February and July, 1969 (Fig. 5). No rafts were in the slough at the time of sampling in February and only a few were present in July. The bottom materials were examined at three extra locations in July.

Sand and silty-sand with varying small amounts of bark and detritus comprised the bottom materials in February and July

Station No.	Station Description
SB-1	Steamboat Slough near north bank about 152 meters below upstream end.
SB-2	Steamboat Slough in mid-channel opposite station SB-1.
SB-3	Steamboat Slough near south bank opposite station SB-1.
SB-4	Steamboat Slough near north bank about 1036 meters below upstream end.
SB-5	Steamboat Slough in mid-channel opposite station SB-4.
SB-6	Steamboat Slough near south bank opposite station SB-4.
SB-7	Steamboat Slough near north bank about 457 meters above downstream end.
SB-8	Steamboat Slough in mid-channel opposite station SB-7.
SB-9	Steamboat Slough near south bank opposite station SB-7.

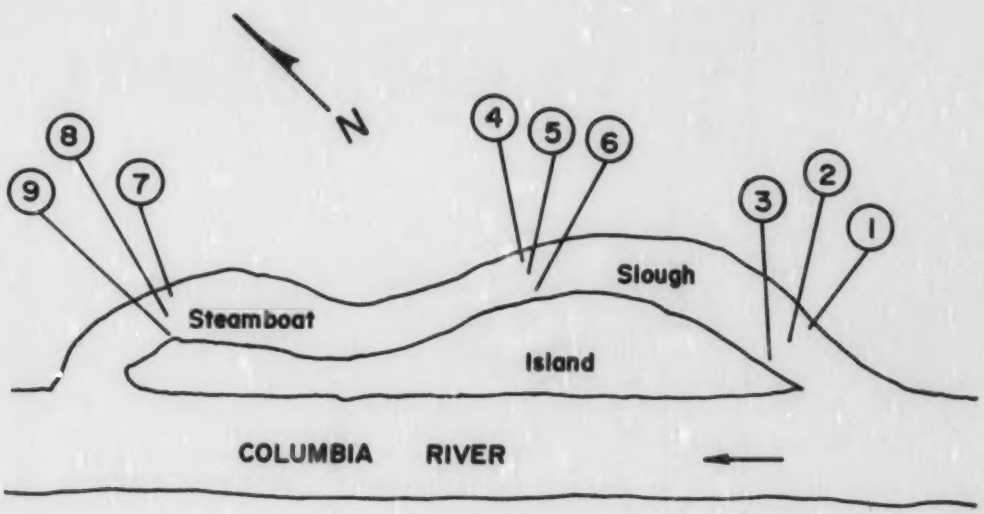

Figure 5. Steamboat Slough study site

Table 10. STEAMBOAT SLOUGH STUDY SITE BOTTOM DWELLING ORGANISMS

Station[a]	No. Genera	No./m^2	Depth (m)	Bottom Type	Volume per sample, cc	
					Bark	Detritus
February 12, 1969						
SB-1	7	7,619	3	Silty-sand, detritus	0	30
SB-2	7	3,811	7.6	Silty-sand, detritus	0	15
SB-3	6	3,434	5.8	Silty-sand, detritus, bark	8	25
SB-4[b]	-	-	7.6	Hard	-	-
SB-5	3	786	7.6	Coarse sand, detritus, bark	10	10
SB-6	5	7,737	7.6	Silty-sand, detritus	0	25
SB-7	9	8,837	7.6	Sand, detritus, bark	5	20
SB-8	5	937	4	Sand, detritus, bark	5	2
SB-9	5	2,412	2.7	Sand, detritus	0	4
July 15, 1969						
SB-1	10	7,081	6.1	Silty-sand, detritus, bark	13	20
SB-2	6	303	4.6	Silty-sand	0	0
SB-3	9	4,251	3.7	Silty-sand, detritus, bark	6	251
SB-4	7	1,398	6.7	Silty-sand, detritus	0	7
SB-5	5	227	7	Silty-sand	0	0
SB-6	4	1,357	6.7	Silty-sand, detritus, bark	5	10
SB-7	6	980	7.6	Silty-sand, detritu, bark	6	1
SB-8	6	270	4.6	Silty sand	0	0
SB-9	4	2,399	.9	Silty-sand, detritus, bark	2	8

[a] One sample per station
[b] No sample.

(Table 10). Bottom samples in February contained 5-10 cc of bark and 2-3 cc of detritus. The bark ranged from 0.7-20 mm wide, to 1.4-140 mm long. No sample could be obtained at SB-4. Similar amounts of bark and detrital material were obtained in July at the majority of stations. Bark ranged from 2-13 cc and detritus from 1-20 cc per grab sample. A large amount of detritus, 251 cc, occurred at SB-3. The bark ranged from 3-65 mm wide, to 6-120 mm long.

Log rafts were moored at SB-5 and SB-6 in July. The bottom materials examined at three additional locations in this area did not differ from the materials at the regular stations. During both seasons there was less bark and detrital material at mid-channel than near the sides of the slough, a probable response to scouring by the current. The water action plus the limited log rafting are the most likely causes of the small amount of bark deposited throughout the slough.

Bottom depths ranged from 2.7-7.6 m in February and from 0.9-7 m in July (Table 10). The water was slightly murky at both seasons; transparency, as measured with a Secchi disc, increased from 0.76 m in February to 1.2 m in July

The chemical water quality did not appear to have adversely influenced the distribution of the bottom dwelling populations (Table 11). Dissolved oxygen was high at both seasons and averaged over 10 mg/l in February and over 13 mg/l in July. PBI was very uniform in February, ranging from 4.8-5.5 mg/l. COD ranged from 9-10 mg/l in July. Relatively higher values of COD, color, turbidity and SS at SB-6 may have been caused by a localized disturbance of the bottom materials.

The predominant bottom-dwelling animals of Steamboat Slough were sludgeworms, marine scuds, midge larvae and asiatic clams. The number of different genera per station ranged from three to nine in February and from four to ten in July. There was no relationship between the number of genera and the bottom type (Table 10, App. E).

In February, the total number of organisms per station averaged 4,447/m^2 and ranged from 786-8,857/m^2. Populations decreased in July; the average number per station was 2,030/m^2 with a range of 227-7,081/m^2. More organisms were collected near the sides than mid-channel. This was probably a response to increased current and lesser amounts of bark and detritus in the mid-stream portion of the slough. The outer stations averaged 6,008 organisms/m^2

Table 11. STEAMBOAT SLOUGH STUDY SITE WATER CHEMISTRY DATE

Sta. No.	Sample Depth (m)	Temp. °C	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
February 12, 1969															
Sb-1	3	2.5	13.8	6.7	118	21	12	20	12	4.8	8		.016	0.7	0.33
SB-2	6.4	2.5	14.2								11				
SB-3	5.8	2.5	14.3	6.7	121	24	5	15	13	5.3	4		.027	0.3	0.42
SB-4	6.4	3.5	13.8	6.4	120	9	2	30	10	5.1	8		.036	0.3	0.42
SB-5	6.4	3.5	13.3								11				
SB-6	6.4	3.5	13.6	6.6	117	105	9	40	23	5	36		.016	0.7	0.33
SB-7	6.4	3.5	13.6	6.9	118	10	2	25	11	5.1	8		.03	0.4	0.44
SB-8	3.7	3.5	13.6								10				
SB-9	2.7	3.5	13.3	6.7	120	34	3	25	13	5.5	13		.025	0.2	0.4
July 15, 1969															
SB-1	6.7	19.0	10.5								10				
SB-3	3.7	18.5	10.8								-				
SB-4	6.7	18.5	10.4	7.4	138	20	3	5	5	3	10	2	.01	0.3	0.05
SB-6	6.7	18.5	10.4	7.4	138	26	3	15	6	3	10	2	.01	0.3	0.06
SB-7	7.6	18.5	-	7.2							9				
SB-9	.9	18.5	-	7.5							9				

Note: DO concentrations at the surface were within 1.0 mg/l of the concentrations observed near the bottom at each station.

and mid-channel stations 1,845/m^2 in February. The average values for July were 2,911/m^2 at the outer stations and only 267/m^2 at the mid-channel stations (Table 10).

Either scuds or sludgeworms were predominant at every station during both seasons with but two exceptions. In July, midge larvae comprised 75 percent of the population at SB-2 and asiatic clams comprised 40 percent at SB-8. No detritus or bark were present at these two mid-channel stations at this time. Scuds comprised 37 to 84 percent of the bottom dwelling animals where they were the predominant forms; sludgeworms made up 43 to 95 percent at stations where they were predominant. There was no relationship between these latter two animals and the varying amounts of either bark or detritus (Table 10, App. E).

The bottom-dwelling animals of Steamboat Slough were not adversely afffected by the small amount of bark deposition. While there were smaller numbers of organisms at stations with less bark and detritus, there was no correlation between the amount of these materials and the type of predominant organisms with the exception of only two instances in July.

The results from this study site indicate that minimal effects upon the bottom-dwelling animals could probably be expected from temporary storage of log rafts in an area subjected to a large flow of fairly good quality water.

ELOCHOMAN AND CATHLAMET SLOUGHS STUDY SITE

Elochoman and Cathlamet Sloughs study site is on the north side of the Columbia River just downstream from Cathlamet, Washington. It includes Cathlamet Slough and a portion of Elochoman Slough (Fig. 6). Log handling and storage activities take place in Cathlamet Slough and on adjacent land on the north shore. Logs brought in by raft and truck are graded, sorted, stored in wet decks, and ultimately transported elsewhere, primarily by log raft, for use or resale. Approximately 260,000 m^3 are handled annually. In 1968 hemlock comprised about 72 percent of the total, with the remainder consisting of spruce, cedar, alder, fir and silver fir.

A crane is used to remove and place logs in the water; they are lowered rather than being dumped. Most logs are banded into bundles by steel bands primarily to give greater capacity to the rafts, but also to prevent sinking and breakage. Accumulated

NOTE: Not to scale.

Some log rafting near
S. bank of Cathlamet Slough.

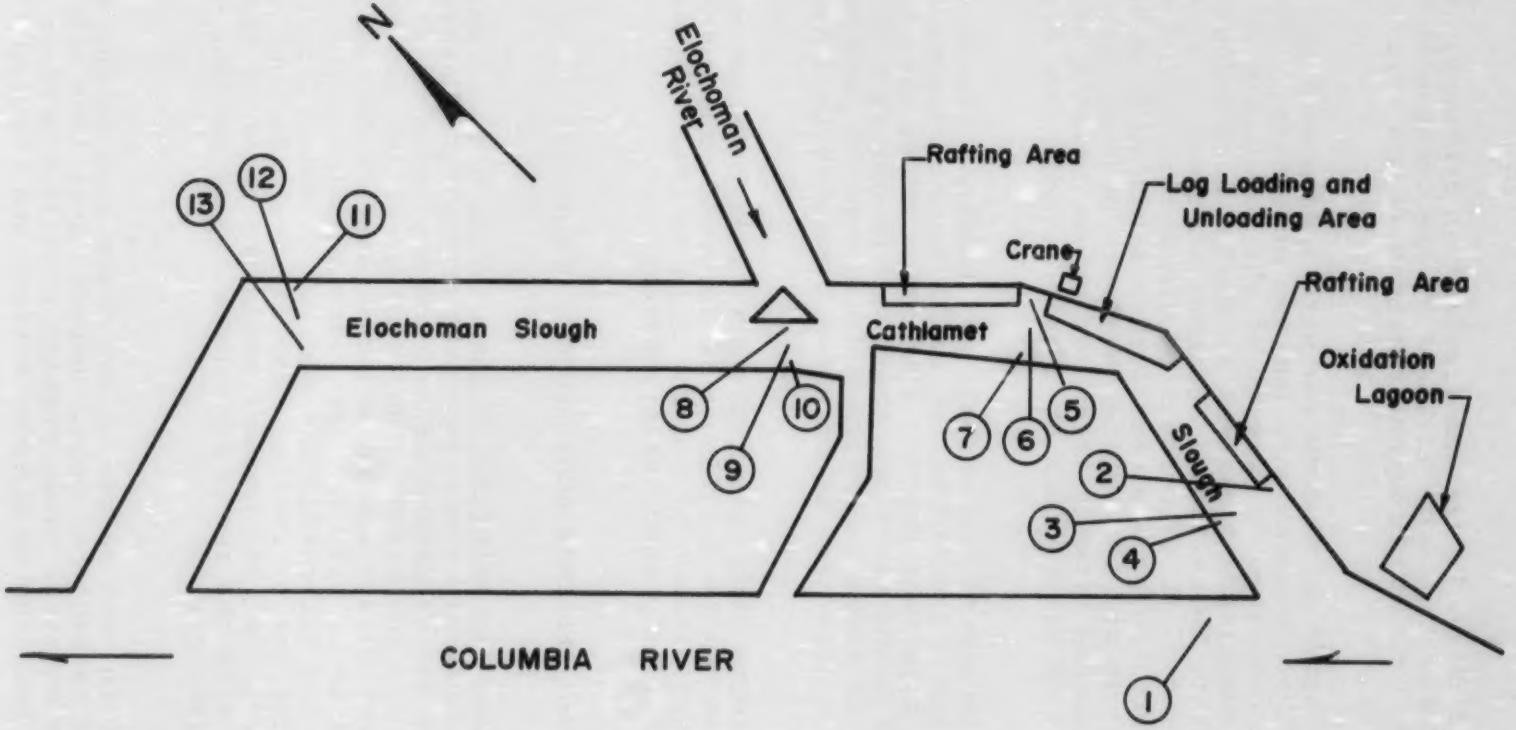

Figure 6. Elochoman and Cathlamet Sloughs study site

bark is dredged from the log loading areas approximately every 2-3 months. The bark was removed in May prior to sampling in July, 1969. About every 4-5 years Cathlamet Slough is dredged down to sand where needed. It was last dredged prior to this study during the winter of 1967-68. Elochoman Slough is limited to temporary storage of log rafts.

Elochoman Slough and Cathlamet Slough are each about 2.4 km long and 60-120 m wide. Water depths are influenced somewhat by tidal fluctuations in addition to seasonal variations in the river level. Salt water does not intrude this far upstream. Although current velocities were not measured in the sloughs, they appear to be considerably less than in the main channels of the Columbia River.

Twelve stations were sampled in Elochoman and Cathlamet Sloughs in February, 1969 (Fig. 6, Table 12). These same stations, with the exception of EC-8, EC-9 and EC-10, were also sampled in July. EC-1 was established in the Columbia River near the entrance to Cathlamet Slough in July. The bottom materials were examined at four extra locations in July in addition to the regular stations.

Combinations of sand and silt with varying amounts of bark and detritus comprised the bottom materials of the study site (Table 13). Bottom samples collected in February contained from 0-110 cc of bark and from 7-320 cc of detritus. The bark ranged in size from 0.7-60 mm wide, to 1.4-125 mm long. No quantitative samples could be obtained at EC-7 and EC-13. In July, the samples contained from 15--190 cc of bark and from 15-210 cc of detritus. The bark ranged in size from 4-50 mm wide, to 6-300 mm long. There were no large bark deposits within the study area. The bottom materials from four additional locations in Cathlamet Slough did not differ from the materials at the regular stations.

Bottom samples were collected from depths of 0.9 - 4.6 m in February and from 2.7 - 4.9 m in July (Table 13). The water was slightly murky at both seasons; transparency, as measured with a Secchi disc, increased from 0.76 m in February to 1.37 m in July. Floating bark chunks were frequently observed in July.

Dissolved oxygen was high at both sampling seasons, ranging from 9.8-13.8 mg/l. There was little difference in levels of chemical constituents throughout the study site at each season. In July, the values were essentially the same in the slough as in the Columbia River at EC-1 (Table 14).

Table 12. SAMPLING STATIONS ELOCHOMAN AND CATHLAMET SLOUGHS STUDY SITE

Station No.	Station Description
EC-1	Columbia River about 152 m downstream from the upstream tip of the island and about 23 m from bank of island.
EC-2	Cathlamet Slough about 152 m downstream from the tip of the island. Near N. bank and just upstream of log rafting area.
EC-3	Cathlamet Slough near mid-channel and opposite station EC-2.
EC-4	Cathlamet Slough near S. bank and opposite station EC-2.
EC-5	Cathlamet Slough near N. Bank and immediately downstream from log loading and unloading area.
EC-6	Cathlamet Slough near mid-channel and opposite station EC-5.
EC-7	Cathlamet Slough near S. bank and opposite station EC-5.
EC-8	Near S. bank of small island at confluence of Elochoman River, Elochoman Slougn, and Cathlamet Slough.
EC-9	Near mid-channel opposite station EC-10.
EC-10	Near S. bank of channel opposite station EC-10.
EC-11	Elochoman Slough near N. bank about 914m upstream from mouth of slough.
EC-12	Elochoman Slough near mid-channel and opposite station EC-11.
EC-13	Elochoman Slough near S. bank and opposite station EC-11.

Table 13. ELOCHOMAN AND CATHLAMET SLOUGHS STUDY SITE BOTTOM DWELLING ORGANISMS

Station[a]	No. Genera	No./m^2	Depth m	Bottom Type	Volume per sample, cc	
					Bark	Detritus
February 11, 1969						
EC-2	5	10,212	3	Silt, detritus, bark	110	7
EC-3	3	6,349	4.6	Sandy-silt, detritus, bark	21	12
EC-4	7	13,311	3.7	Sandy-silt, detritus, bark	7	100
EC-5	12	28,472	3.4	Silt, detritus, bark	80	320
EC-6	4	1,669	4.3	Silty-sand, detritus, bark	70	50
EC-7 [b]	-	-	3	Sandy-silt, detritus, bark	-	-
EC-8	10	16,098	.9	Sandy-silt, detritus, wood	0	95
EC-9	11	13,452	1.5	Silty-sand, detritus, wood	0	60
EC-10	5	281	4.3	Sand, detritus, bark	3	3
EC-11	10	13,914	2.1	Silty-sand, detritus, bark	20	45
EC-12	8	2,714	3.1	Silty-sand, detritus, bark	20	45
EC-13 [b]	-	-	2.4	Sand, detritus, bark	-	-
July 14, 1969						
EC-1 [1]	5	722	5.2	Silty-sand, detritus, bark	15	80
EC-2	9	11,030	4.6	Silty-sand, detritus, bark	30	70
EC-3	4	10,219	4.6	Silty-sand, detritus, bark	15	55
EC-4	6	6,834	2.7	Silty-sand, detritus, bark	95	80
EC-5	4	13,636	4.9	Silty-sand, detritus, bark	70	150
EC-6	8	20,025	4.9	Silty-sand, detritus, bark	40	210
EC-7	8	5,210	4.6	Silty-sand, detritus, bark	190	70
EC-11	11	4,241	3	Silty-sand, detritus, bark	150	65
EC-12	6	1,043	3	Silty-sand, detritus, bark	25	15
EC-13	7	2,669	3	Silty-sand, detritus, bark	110	19

[a] One sample per station.

[b] No sample.

[c] Columbia River.

Table 14. ELOCHOMAN & CATHLAMET SLOUGHS STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Sample Depth (m)	Temp. °C	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
February 11-12, 1969															
EC-3	4.6	3.0	12.4	6.7	124	10	4	25	8	4.2	4		.026	0.3	0.43
EC-6	4.3	3.0	13.4	6.8	126	20	5	25	10	3.9	<1		.028	0.3	0.42
EC-9	1.2	5.0	11.6	6.5	43	50	9	50	22	3.2	<5		.011	0.3	0.45
EC-12	3	3.0	13.8	6.5	108	18	5	30	10	4.4	5		.022	0.3	
July 14, 1969															
EC-1	5.2	19.0	9.8	7.4	130	8	1	15	6	2	5	1			
EC-1	Sample collected on July 15												.011	0.5	0.05
EC-3	4.6	18.5	10.1	6.5	131	20	3	15	7	2	13	2	.011	0.4	0.11
EC-6	4.9	18.5	9.8	7.0	130	21	<1	20	7	2	15	1			
EC-12	2.7	19.0	9.8	7.4	130	10	1	10	10	3		2			
EC-12	Sample collected July 15														

Note: DO concentrations at the surface were within 1 mg/l of DO concentrations near the bottom for each station.

The predominant bottom-dwelling organisms of Cathlamet and Elochoman Sloughs were sludgeworms, marine scuds, asiatic clams, and midge larvae. The average number of organisms per square meter was 10,647 in February and 8,323 in July (Table 13, App. F).

The bottom populations indicated degradation at stations EC-2 to EC-7 and better conditions at stations EC-8 to EC-13. No rafts were present at the time of sampling at stations EC-2 to EC-4. Log loading and unloading and raft construction and storage were concentrated in the area near stations EC-5 to EC-7. The areas near stations EC-8 to EC-13 were not used for rafting.

Sludgeworms, often common inhabitants of areas subjected to organic enrichment or pollution, comprised 96 to 98 percent of the organisms at the stations in Cathlamet Slough in February and from 94 to 98 percent in July. Improved conditions at stations EC-8 to EC-10, sampled only in February, were indicated by populations comprised of 54 to 70 percent sludgeworms, 19 to 20 percent scuds and 7 to 14 percent midge larvae (Table 13, App. F).

The biologically degraded section of the study site had fewer kinds of organisms, higher populations, and more bark and detritus than the lower reaches. In February a comparison of the average values between the five degraded upstream stations and the five improved downstream stations showed that the genera increased from six to nine per station, and the number of organisms decreased from 12,040 - 9,286 per m^2. The volume of bark decreased from 58 - 0.6 cc per sample, and the volume of detritus decreased from 98 to 56 cc per sample.

The smaller amounts of detritus and generally smaller amounts of bark in the biologically improved downstream area strongly suggests that the log handling activities in the upper reaches have had an adverse effect upon the bottom-dwelling animals. It seems likely that the larger amounts of detrital material in the upstream reaches were contributed to in large part by the unloading, loading, and rafting activities. Decomposition of the bottom materials at the upper stations probably produced a habitat more conducive to the establishment of animal populations tolerant to organically enriched conditions.

A municipal sewage lagoon in the town of Cathlamet just upstream from the entrance of Cathlamet Slough may have partially contributed to the degraded conditions of the upper portion of

the study area. It was unlikely that the intermittent discharge from the lagoon would always flow into the slough but the possibility of some organic pollution from this source does exist. The results of this study suggest that log rafting activities in a comparatively sluggish slough can adversely affect the populations of bottom-dwelling animals.

COAL CREEK SLOUGH STUDY SITE

Coal Creek Slough study site is on the north edge of the Columbia River downstream from Longview, Washington. It includes most of Coal Creek Slough, which is used for log storage, and a small portion of Solo Slough. Log rafts extended along most of the length of the former slough during sampling in July, 1969; there were some wet decks in this area also. Approximately 190,000-212,000 m^3 of logs in rafts pass through the slough annually. Average storage time is about four months for the rafts and about one year in the wet decks. Douglas-fir make up about 60 percent of the logs with western red cedar the remainder.

Coal Creek Slough is about 9 km long and 30-122 m wide. Coal Creek flows into the slough near its upper end. There are two pumping stations that pump from adjacent low-lying lands into the slough. One of the stations is located at the upstream end of the slough and the other about one-third of the distance upstream from the slough's mouth. The pumps work intermittently; on the day samples were collected they were not operating. Water in the ditches leading to the downstream pump station was highly turbid. Cattle pastures are located adjacent to some of the drainage ditches.

Nine sampling stations were established at this site (Fig. 7, Table 15). Six were located in Coal Creek Slough in heavily rafted areas; three were located upstream in Solo Slough, a non-rafted area. The bottom materials were examined briefly at six additional locations.

Virtually stagnant water, low levels of dissolved oxygen and bottom-dwelling animals tolerant of enriched or polluted conditions were common throughout the study site. Extensive bark deposits characterized Coal Creek Slough and were absent from Solo Slough.

The bottom of Solo Slough was silty and contained from 60 - 120 cc of detritus per sample. Silt, organic ooze, detritus and bark

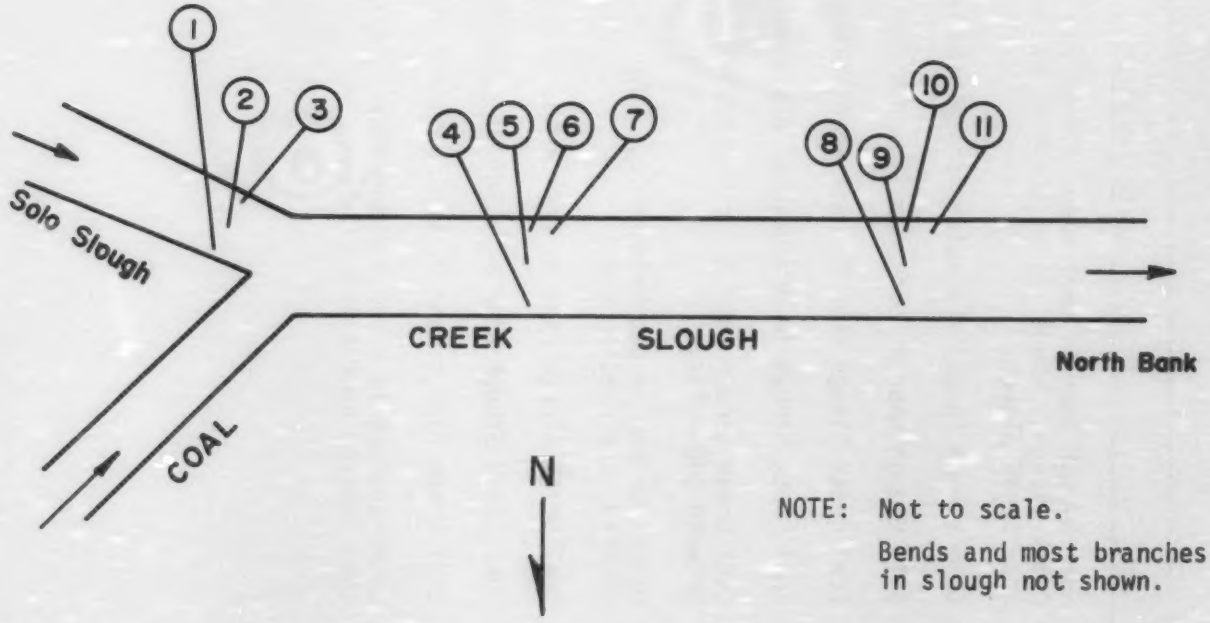

Figure 7. Coal Creek Slough study site

Table 15. SAMPLING STATIONS COAL CREEK SLOUGH STUDY SITE

Station No.	Station Description
C-1	Solo Slough near E. bank about 7.9 km above mouth of Coal Creek Slough. About .24 km south of where highway crosses Coal Creek Slough.
C-2	Solo Slough in mid-channel opposite station C-1.
C-3	Solo Slough near W. bank opposite station C-1.
C-4	Coal Creek Slough near N. bank about 6.4 km above mouth.
C-5	Coal Creek Slough in mid-channel opposite station C-4.
C-6	Coal Creek Slough near S. bank opposite station C-4. In gap between log rafts.
C-7	Water surface in gap between logs in a raft of cedar logs located near station C-6.
C-8	Coal Creek Slough near N. bank about 7.2 Km above mouth.
C-9	Coal Creek Slough near mid-channel opposite station C-8.
C-10	Coal Creek Slough near S. bank opposite station C-8.
C-11	Water surface in a gap between logs in a raft of Douglas-fir logs located near station C-10.

comprised the bottom at most of the stations in Coal Creek Slough (Table 16). Large pieces of bark frequently prevented the Ponar grab from closing and obtaining a quantitative sample. Bark which remained in the dredge ranged from 5 - 50 mm wide to 25 - 450 mm long. The bottom materials were examined at six locations throughout the length of Coal Creek Slough in addition to the regular sampling stations. Bark and wood fragments were common throughout the study area. Strands of cedar bark up to six feet long and small gobs of natural resin were frequently encountered in the lower reaches of the slough.

The water was 2.7 m deep in Solo Slough and ranged from 3.4 to 10.4 m deep in Coal Creek Slough (Table 16). No flow was observed throughout the study site and the water was dark and murky. Transparency, as measured with a Secchi disc, was 1.4 m in Coal Creek Slough.

Dissolved oxygen was low, averaging about 5 mg/l in Solo Slough and only 3 mg/l in Coal Creek Slough. The values in the latter slough were below those considered marginal for a healthy aquatic community. Other chemical constituents varied little throughout the site. The COD averaged over 24 mg/l, higher than at the other log rafting sites (Table 17).

The predominant bottom-dwelling animals in both sloughs were sludgeworms, common inhabitants of enriched or polluted environments. They comprised 95 to 98 percent of the approximately 3,268 organisms/m^2 in Solo Slough. In Coal Creek Slough they made up 93 to 96 percent of the 5,531 to 8,597 organisms/m^2 at C-5 and C-6 and appeared to be the predominant animals in the non-quantitative samples (Table 16, App. G).

Solo Slough, not subjected to log rafting, did not seem to be of any better quality based on kinds and numbers of bottom-dwelling organisms than heavily rafted Coal Creek Slough. Degraded biological conditions were apparent in both sloughs. Since only stations C-5 and C-6 in Coal Creek Slough could be sampled quantitatively, precise comparisons between the bottom populations and bark deposits of the two sloughs were not possible. The low level of dissolved oxygen in Solo Slough was very likely influenced by the extensive bark deposits in Coal Creek Slough. The predominance of sludgeworms in both sloughs was a probable response to these low oxygen levels.

The lack of flow throughout the study area was certainly a major contributing factor to the degree of pollution. Tidal

Table 16. COAL CREEK SLOUGH STUDY SITE BOTTOM DWELLING ORGANISMS

Station[a]	No. Genera	No./m^2	Depth m	Bottom Type	Volume per sample, cc	
					Bark	Detritus
July 16, 1969						
C-1	3	3,369	2.7	Silt, detritus	0	62
C-2	4	3,088	3	Silt, detritus	0	120
C-3	3	3,347	2.7	Silt, detritus	0	120
C-4[b]	4	-	3.4	Silt, ooze, detritus, bark	-	-
C-5	4	5,531	6.4	Silt, ooze, detritus, bark	25	90
C-6	6	8,597	6.1	Silt, ooze, detritus, bark	90	70
C-8[b]	3	-	6.7	Hard	-	-
C-9[b]	6	-	10.4	Silt, ooze, detritus, bark	-	-
C-10[b]	5	-	6.7	Silt, ooze, detritus, bark	-	-

[a] One sample per station.

[b] Non-quantitative sample only.

Table 17. COAL CREEK SLOUGH STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Sample Depth m	Temp. °C	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
July 16, 1969															
C-2	0	19.0	5.7												
C-2	2.7	19.0	4.7	6.9	257	16	4	50	12	<1	27	2	.011	0.8	.09
C-4	0	21.0	3.6												
C-4	3.4	19.0	3.6	6.8	227	14	3	50	10	<1	20	2	.019	0.9	.1
C-6	0	20.0	3.9												
C-6	6.1	18.5	3.7	6.8	232	52	6	50	22	3	26	1	.021	0.8	.1
C-7	0										36				
C-8	0	20.0	3.0												
C-8	6.7	19.0	2.4								17				
C-10	0	20.0	3.0												
C-10	9.8	19.0	1.6								22				
C-11	0										22				

fluctuations in the Columbia River probably resulted in some back and forward movement of water but its diluting effects would have been minor. Since the oxygen demand exerted by the decomposing bark was not satisfied by fresh water coming from upstream, it consequently lowered what little oxygen was available in the immediate area. The lower dissolved oxygen levels and organic ooze in the bottom deposits of Coal Creek Slough demonstrate an aspect of damage to the aquatic environment by extensive bark deposits.

MULTNOMAH CHANNEL STUDY SITE

Multnomah Channel study site is on the western edge of the Multnomah Channel near Scappose, Oregon. The site includes a raft make-up area and a raft storage area. Logs are hauled to the site by truck, lowered into the water by a crane, graded, sorted, and grouped into rafts. Smaller logs are banded into bundles. About 47,000 m^3 are handled annually. There are raft storage areas scattered along both shores upstream and downstream from the study site; however, the total amount of log handling in Multnomah Channel was not determined.

Multnomah Channel is part of the Willamette River. It branches off from the main channel about 3.2 km upstream from the mouth and flows into the Columbia River at St. Helens, Oregon. The channel is about 34 km long and about 122 - 305 m wide. Tidal action extends this far upstream. A computer study of the Columbia River shows that under some low flow conditions the flow in Multnomah Channel would be reversed during high tide (Callaway 1970). Waste discharges to the Willamette River in the Portland-Oregon City area have some effect on water quality in Multnomah Channel. No attempt was made during this study to evaluate the changes in water quality due to these other waste sources. Six stations were established within and near the log unloading and rafting area and were sampled in August, 1969 (Fig. 8).

The bottom of the Multnomah Channel in the study area was basically silty-sand (Table 18). Bark and detritus deposits were also present within the unloading and raft make-up area but only small amounts of bark were collected at M-6 across the channel. Downstream from the unloading area at M-5 the bottom was very hard; no sample could be collected. Some bark, 150 cc, was in the bottom sample collected in the immediate unloading area at M-2. Downstream from this station at M-3, 270 cc of bark were collected. This increase was probably due to water current, both natural and that set up by the unloading of the bundled logs. Detrital material, equal in volume to the amount of bark at these

Station No.	Station Description
M-1	Multnomah Channel near west bank about 140-180 meters upstream from log unloading area.
M-2	Multnomah Channel at log unloading area.
M-3	Multnomah Channel about 25 meters from west bank and 75 meters downstream from log unloading.
M-4	Across the channel from Station M-2. About 15 meters from east bank.
M-5	Multnomah Channel near west bank approximately .5 km below log unloading area.
M-6	Across the channel from Station M-5. About 15 meters from east bank.

Note: Not to scale.

Curve in channel not shown.

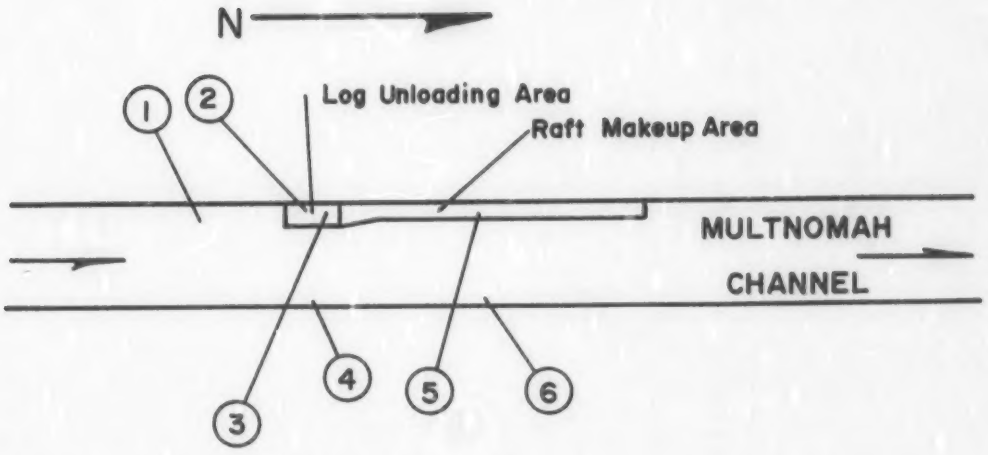

Figure 8. Multnomah Channel study site

Table 18. MULTNOMAH CHANNEL STUDY SITE BOTTOM DWELLING ORGANISMS

Station[a]	No. Genera	No./m^2	Depth m	Bottom Type	Volume per sample, cc	
					Bark	Detritus
August 12, 1969						
M-1	1	560	5.5	Silty-sand	0	90
M-2	3	431	2.1	Silty-sand, gravel, detritus, bark	150	160
M-3	8	5,145	5.8	Sandy-silt, gravel detritus, bark	270	250
M-4	3	474	9.8	Sandy, detritus	0	22
M-5[b]	-	-	12.2	Hard	-	-
M-6	5	2,292	7.6	Silty-sand, detritus, bark	6	5

[a] One sample per station

[b] No sample

two stations, was probably associated with the logging activities since very little of it was found upstream or across the channel. The bark collected in the samples ranged from 40-55 mm wide and from 6-150 mm long. Small amounts of natural resin were found in the bottom materials at each station except M-5. Gas bubbles, presumably from anaerobic decomposition, were observed on a reconnaissance survey in October, 1968.

The water was only 2.1 m deep at the unloading area and increased to 12.2 m at M-5 (Table 18). Transparency, as measured with a Secchi disc, was 0.91 m. The water, murky at all stations, was characterized by a piney or resinous odor in the vicinity of the unloading area.

Chemical water quality was fairly uniform at all stations. Dissolved oxygen was somewhat low (5.1-5.3 mg/l), near the marginal level for a healthy balanced aquatic community. Organics were also low as indicated by the COD (9-11 mg/l) and BOD (1-2 mg/l) concentrations. Suspended solids ranged from 16-28 mg/l and were mainly inorganic (Table 19).

The poor water quality of the Multnomah Channel was reflected by the predominance of sludgeworms at each station (App. H). These organisms, often associated with enriched or organically polluted conditions, comprised from 93 to 100 percent of the population at stations M-1, M-2, M-3 and M-6. Slightly better quality was indicated across the channel at M-4 where scuds made up 20 percent and sludgeworms 77 percent of the population. However, M-6, also across the channel, had 93 percent sludgeworms.

Station M-3, with 5,145 organisms/m^2, had from two to ten times more organisms than the rest of the stations. Although more variety was indicated by the eight different genera present here, serious degradation was still shown by the sludgeworms which comprised 94 percent of the population. The larger amounts of detritus at this station probably represented a habitat more conducive to increases in numbers and variety than did plain, silty-sand bottom materials (Table 19).

Water quality in this section of the Multnomah Channel was degraded, particularly biologically. Bark deposits were not extensive and were generally limited to the unloading and rafting area. However, the bottom dwelling organisms indicated degradation was common even across the channel from the handling activities. The small number of samples collected were inconclusive as to whether conditions were better or worse within

Table 19. MULTONOMAH CHANNEL STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Sample Depth m	Temp. °C	DO (mg/l)	pH	Cond. µmho	SS (mg/l)	VSS (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
August 12, 1969															
M-2	2.1	21	5.3	6.0		16	2	25	5		11	2	0.26	0.22	0.44
M-3	4.3	21	5.2			20	2	25	6		9	1			
M-4	10.7	21	5.2	6.8		28	4	30	8		10	2	0.21	0.26	0.44
M-5	12.2	21	5.1	6.2		24	4	15	5		9				
M-6	7.62	21	5.1	6.6		22	1	15	6		10				

or outside of the unloading area. There is little doubt that if the entire channel contained extensive bark deposits with their subsequent smothering action and anaerobic decomposition, the presently degraded conditions would only worsen.

SIUSLAW RIVER STUDY SITE

Siuslaw River study site extends from Mapleton, Oregon, to about 7.6 km downstream. Just downstream from Mapleton there is a sawmill, stud mill and a plywood mill. Logs are stored in wet decks and when needed are debarked and placed in the water along the north bank. Peeler cores from the plywood mill are temporarily stored in the river until used in the stud mill. About 142,000 m^3 of logs are handled annually, mainly fir with some hemlock.

There is another sawmill about 7.2 km downstream from Mapleton. Logs are trucked to this sawmill, dumped into the river, grouped into rafts and stored until needed. The raft storage area extends about 1.6 km upstream and 21 km downstream from the sawmill. Approximately 70,000 m^3 of logs, consisting of 85 percent fir, 10 percent hemlock, and 5 percent cedar, are handled annually. The inventory of logs in storage is usually about 12,000 m^3, but may go as high as 21,000 m^3.

The Siuslaw River drains an area of 2,002 ha and flows into the Pacific Ocean. Most of the area upstream from the study site is forested. Precipitation in the area varies from 101 to 254 cm. Duringlow flow in the summer, salt water intrudes as far upstream as Mapleton, 32 km from the ocean. Domestic waste disposal at Mapleton, population 700, is by septic tanks. There does not appear to be any significant waste discharges upstream from the town.

The Siuslaw River is a good coho salmon, steelhead and cutthroat trout producer. It also has a good fall chinook run. Most of the fish production occurs in the tributaries since these have lower summer water temperatures and greater quantities of spawning gravel (OSWRB 1965).

Ten sampling stations established in log dumping and rafting areas were sampled during September, 1969 (Fig. 9, Table 20).

NOTE: Numerous log rafts tied along the river are not shown in the diagram below.

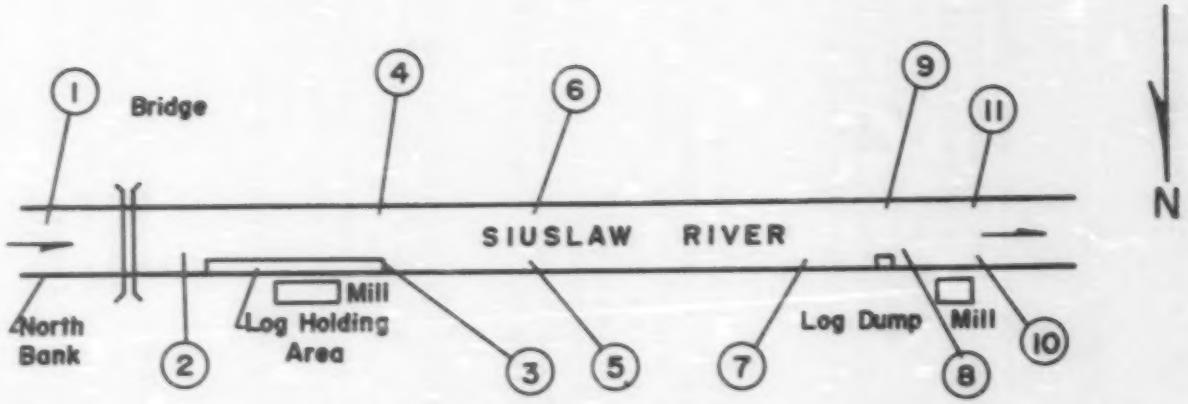

Figure 9. Siuslaw River study site

Table 20. SAMPLING STATIONS SIUSLAW RIVER STUDY SITE

Station No.	Station Description
S-1	Siuslaw River approximately 0.8 km upstream from bridge.
S-2	Siuslaw River near N. bank about 0.8 km downstream from bridge.
S-3	Siuslaw River near N. bank about 3.2 km downstream from bridge.
S-4	Across river from station No. S-3.
S-5	Siuslaw River near N. bank about 4 km downstream from bridge. In gap between two log rafts.
S-6	Across river from station S-5. In gap between two log rafts.
S-7	About 6.4 km downstream from bridge. In gap between two log rafts.
S-8	Siuslaw River about 7.2 km downstream from bridge. About 22.8 m downstream of log dump on N. bank.
S-9	Across the river from station S-8.
S-10	Siuslaw River near N. bank about 7.6 km downstream from bridge. About 180-275 m downstream from mill.
S-11	Across the river from station S-10.

The bottom of the Siuslaw River study area was mainly silty-sand with varying amounts of bark and detritus (Table 21). Although no large bark deposits were observed, no station where a sample could be collected was without some bark. A hard bottom prevented quantitative sample collecting at S-4 and S-11. Ooze, with an odor typical of anaerobic decomposition, was the predominant material at S-8 near the log dump. This sample also contained 215 cc of bark, almost 3 to over 40 times as much as at the other locations. The bark at all the stations combined ranged in size from 4-40 mm wide, to 10-200 mm long. Natural resin was found in samples at S-2, S-5, S-6, S-8, and S-10. The samples at stations S-3 to S-7 contained from 8-50 cc of detrital material while about 200 cc were collected at stations S-8 to S-10.

Transparency, as measured with a Secchi disc, was about 1.8 m throughout the study area. The water was 7.9 m deep at S-8 near the log dump; depths at the other stations ranged from 3.4 to 4.6 m (Table 21). Numerous bark chunks were floating on the surface throughout the area.

Dissolved oxygen was low throughout the study site(4.5-6.3 mg/l) and tended to be marginal for a healthy aquatic community upstream at station S-1. There was little difference in oxygen concentration from the surface to the bottom at several of the stations. Color, turbidity, PBI and nitrogen were all fairly uniform. COD ranged from 6-8 mg/l at most of the stations and was at 12 and 26 mg/l at stations S-1 and S-10, respectively. Salt water intrusion was reflected in the increase in chlorides as the river progressed downstream. Chlorides in the upper reaches were about 10 percent of that expected in the ocean; values in the lower reaches were about 25 percent (Table 22).

Station S-2 was upstream from a section of the river used for barked log storage; station S-3 was just downstream from this area (Figure 9). The bottom was degraded at both locations as indicated by the high percentage of sludgeworms, about 98 percent of the 21,016 and 10,342 organisms/m^2 at these two stations, respectively (App. I). Slightly better conditions may have existed at S-2, however. Ten different genera were collected at this station and only five at S-3. This increased variety may have been a response to the larger amounts of detritus at the upstream station. One hundred fifty cc of detritus were in the sample from S-2, five times as much as at S-3. Bark deposits at both stations were minimal. Station S-4, across the river from S-3, could not be sampled quantitatively (Table 21).

Table 21. SIUSLAW RIVER STUDY SITE BOTTOM-DWELLING ORGANISMS

Station [a]	No. Genera	No./m^2	Depth (m)	Bottom Type	Volume per sample, cc: Bark	Volume per sample, cc: Detritus
September 12, 1969						
S-2	10	21,016	3.4	Silty-sand, detritus, wood, bark	15	150
S-3	5	10,342	3.7	Silty-sand, detritus, wood, bark	5	30
S-4 [b]	3	--	3.7	Hard	--	--
S-5	5	10,276	3.7	Silty-sand, gravel, detritus, wood, bark	8	50
S-6	5	4,197	3.7	Silty-sand, gravel, detritus, wood, bark	14	8
S-7	6	2,486	3.7	Silty-sand, detritus, bark	80	9
S-8	6	5,079	7.9	Ooze, silt, detritus, bark	215	200
S-9	9	7,232	3.7	Silty-sand, detritus, bark	40	210
S-10	12	12,904	4.6	Silty-sand, detritus, bark	12	210
S-11 [c]	--		4.6	Hard	--	--

[a] One sample per station.

[b] Non-quantitative sample.

[c] No sample.

Table 22. SIUSLAW RIVER STUDY SITE WATER CHEMISTRY DATA

Sta. No.	Time PBT	Sample Depth m.	Temp. °C	DO (mg/l)	pH	Cl (mg/l)	Color Pt. Co.	Turb. Jksn	PBI (mg/l)	COD (mg/l)	BOD (mg/l)	Ortho-P (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
September 10, 1969														
S-1	1040	4	20.5	4.5	6.4					12				
S-2	1010	3	20.0	5.1	6.5	1790	15	4	2	8	<1	.002	0.4	.02
S-3	1115	3	20.0	5.8	6.7	1960	15	3	2	6	<1	.003	0.5	<.02
S-3	1120	0	20.0	6.3										
S-4	1135	3		5.2	6.5	2100	15	5	2	6	2	.01	0.4	<.02
S-4	1140	0		5.9										
S-8	1335	7.3	20.5	5.9	6.4	4820	15	4	1	6	<1	.04	0.4	.02
S-8	1340	0		5.9										
S-9	1350	3		5.9	6.4	4620	15	5	1	5	1			
S-10	1410	3.4	20.5	6.2	6.8					26				
S-11	1425	4.6			6.4					6				

Tide appeared to be coming in throughout the time of sampling. In a mixture of fresh and ocean water the solubility of oxygen decreases as the salinity increases. With zero chloride concentration the solubility is 9.2 mg/l at 20°C as compared to 8.7 at a chloride concentration of 5,000 mg/l.

Stations S-5 and S-6, on opposite sides of the river from each other, were both adjacent to log rafts (Fig. 9). Sludgeworms comprised from 94 to 98 percent of the bottom dwelling animals at both locations. Total populations ranged from 10,276/m^2 at S-5 to 4,197/m^2 at S-6. Only five genera were collected from each of these stations. There were 50 cc or less of detritus and up to 14 cc of bark in the samples collected here (Table 21, App. I).

Station S-7 was farther downstream in a rafting area (Fig. 9). Only slightly over 2,475 organisms /m^2 were collected here,. Sludgeworms comprised only 19 percent of the bottom animals while a type of scud common in marine waters made up 48 percent. This sudden decrease in sludgeworms is difficult to explain since the bottom type was not essentially different from station S-6 upstream. The large increase in scuds may have been a response to increasing salinity (Table 21, App. I).

Degraded conditions were evident at S-8, just downstream from a log dump (Fig. 9). Sludgeworms comprised 77 percent of the bottom-dwelling animals, pollution-tolerant red midge larvae 12 percent and scuds only 3 percent. The amount of bark in the sample at this station was 215 cc, while across the river at S-9 there were only 40 cc. Slightly better conditions at S-9 may have been indicated by a small decrease in the percentage of sludgeworms to 70 percent and an increase in scuds to 12 percent. No red midge larvae were collected here. Total numbers of organisms ranged from 5,079/m^2 at S-8 to 7,232/ m^2 at S-9 (Table 21, App. I).

Station S-10 was on the same side of the river and downstream from S-8 in an area free from log rafts (Fig. 9). Over 12,900 organisms/m^2 were collected here. Sludgeworms made up only 29 percent of the population, scuds 58 percent and red midge larvae 14 percent. Polychaete worms, usually found in brackish or marine waters, comprised 6 percent of the animals. Increased varity and seemingly better quality was indicated by 12 different genera collected at this station. Only 12 cc of bark were in the bottom sample from this location; the amount of detritus was the same as at the two previous stations, about 200 cc. No sample could be collected across the river at station S-11 (Table 21, App. I).

Comparisons between the bottom-dwelling animals of the Siuslaw in areas subjected to log dumping or rafting to populations in areas not used for these activities are very difficult. The relatively small number of samples collected at this study site can only indicate what conditions actually are and perhaps emphasizes some

possible problems. The seemingly better conditions, as indicated by the bottom dwelling animals, at S-10 may also have been an indicator of increased salinity in this area of the study site and not necessarily a response to improved bottom conditions.

Aquatic scuds are commonly associated with good water quality; however, the scuds in this area of the Siuslaw River were a marine type, certain species of which can adapt to brackish or fresh water. Their presence in the lower reaches was a more probable response to the increased salinity than improved bottom conditions. These organisms were found with varying amounts of bark and detritus and were not definitely associated more with one material or the other.

Most sludgeworms, or oligochaetes , are fresh water forms and are not generally found in areas subjected to salt water. Their decrease in the lower reaches and predominance at the upstream stations was a very probable response in the increasing salinity. The sludgeworms were also found with varying amounts of bark and detritus.

The number of different genera per station were related to the amount of detritus in each sample. Five to six genera were found in samples with 8 - 50 cc of detritus while 9-12 genera were found in samples with 150-210 cc of detritus. No such relationship was apparent between the number of genera and the amount of bark.

Decomposing bark and other bottom materials could be a cause of the generally low dissolved oxygen values (4.5 - 6.3 mg/l). In addition, low river flow accompanied by current reversals due to tidal action probably prevent a needed constant flushing with fresh water from upstream. Additional or larger deposits of decomposing bark on the bottom in this situation could only serve to worsen conditions and also could be a threat to anadromous fish migration.

Esthetically, log rafting activities in this section of the Siuslaw River were responsbile for a reduction in the recreational value of the stream. Numerous bark chunks and other logging debris were frequently observed on the surface.

SECTION VII
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